EVOSTC FY17-FY21 INVITATION FOR PROPOSALS
RESPONSE TO REVIEWER COMMENTS

PROJECT NUMBER 17120111-D

PROJECT TITLE
Herring Research and Monitoring Program: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (*Clupea pallasii*) in Prince William Sound, Alaska

PRIMARY INVESTIGATOR AND AFFILIATION
Kristen B. Gorman, Prince William Sound Science Center (PWSSC), P.O. Box 705, Cordova, AK 99574

DATE RESPONSE SUBMITTED
August 12, 2016

RESPONSE TO REVIEWER COMMENTS (see INVESTIGATOR RESPONSES 1-5)

Science Panel Comments – FY17
Date: May 2016

The four objectives are:
(1) assess the seasonal timing (spring, summer, and fall) that allows for accurate determination of both previously spawned and maturing female herring based on ovary histology to determine maturation states;
(2) couple histology results with annual scale growth information at the individual level, within specific age cohorts, to understand if scale growth patterns reflect reproductive investment;
(3) assess whether annual scale growth patterns can be used to infer age at maturity at the individual level across age cohorts given results from objectives 1 and 2; and
(4) assess inter-annual variability in age at maturity based on coupled histology and scale growth over a five-year period by focused, increased sampling during the optimal seasonal period given results from objectives 1-3.

This is an ambitious project and the Panel endorses the intentions of the proposed work, but not necessarily all of the details. First, and most importantly, the Panel strongly endorses the objective of determining an 'empirical' estimate of 'age-at-maturity'. It is widely recognized that spawning herring often show spatial and temporal segregation during spawning, with larger, older fish spawning early and smaller, younger fish spawning later. This is well documented for herring and for many other spring-spawning fish species. Ignoring this, by assuming that the age structure of samples taken during spawning represents the population at large can lead to serious errors in age-structured- assessments. Therefore to the extent that this proposal recognized that issue, the Panel is strongly supportive (see AUTHOR RESPONSE 1). To this end the Panel recommends the measurement of gonad size, and the estimation of a gonosomatic index, as the basis for estimating maturity of individuals. Collection of size data will also allow estimation of size-at-maturity, which may be important, as well (see AUTHOR RESPONSE 2).

The Panel also reiterates comments made on the age-structured model here about the likelihood that there is temporal and spatial structuring of herring with respect to size- and age-at-maturity. Estimation of age-at-maturity should keep such temporal and spatial structuring in mind when considering sampling protocols and data analysis (see again AUTHOR RESPONSE 1).

Objectives 2-4 of this proposal are concerned with herring scales and the assumption that growth increments (or some other feature of scales) can provide a meaningful estimate of the age-of-maturation of a herring. If this were possible, the Panel agrees that such a measure would useful, providing the criteria were rigorous and repeatable. However, the Panel has several concerns. One is that this proposal makes no mention of similar work that was recently conducted, and supported by the EVOSTC, by NOAA staff. Namely, is there evidence that this approach will work? This comment applies especially to the proposed study on scales, as potential indicators of age-of-maturity, and ovarian histology objectives. Insufficient information was provided to allow the Panel to evaluate the chances for success of this portion of the proposal. It is essential that this proposal shows that the proposed work will build on existing results and knowledge. Absent some basis for this approach, the Panel is rather dubious of the chances for its success (see AUTHOR RESPONSE 3). The second concern is that there are a number of publications on herring and clupeid maturation, and criteria used for assessing maturation. The revised proposal should make it clear that the PI is aware of this work, and when appropriate, build on the existing knowledge base (see AUTHOR RESPONSE 4). Finally, the Panel does not understand why this work is proposed for five years. It should not require more than a year, or two, to evaluate the utility of scales as indicators of past maturity. The proposal should be revised accordingly (see AUTHOR RESPONSE 5).

Science Coordinator Comments
May 2016
I concur with the Science Panel's comments.

Executive Director Comments – FY17
Date:

Public Advisory Committee Comments – FY17
Date:

Trustee Council Comments – FY17
Date:

AUTHOR RESPONSES

1. This proposal does recognize the important issue of spatial and/or temporal segregation among spawning and non-spawning herring (i.e., spatial segregation), or older more experience fish and younger less experienced fish (i.e., temporal segregation). The first two objectives of the study aim to: 1) assess the seasonal timing (spring, summer, and fall) that allows for accurate determination of both previously spawned and maturing female herring based on ovary histology to determine maturation states; 2) couple histology results with annual scale growth information at the individual level, within specific age cohorts across seasons, to understand if scale growth patterns reflect reproductive investment. Because we plan, over the first two years of the study, to initially sample across seasons (spring, summer, and fall), we anticipate being able to capture spawning and non-spawning cohorts of the PWS population throughout the year. To additionally address this concern of the EVOS Science Panel, we have developed a more comprehensive plan for sampling during spring spawning that includes sampling over the duration of the spawning event to capture any temporal variation in spawning due to age/experience. In addition, during spring spawning, we plan to aerially survey Prince William Sound to identify and sample groups of herring not associated with the main spawning event. Because our original ship time for spring spawn sampling was leveraged with age, sex, and length sampling by ADF&G, we were essentially constrained to spatially sample where ADF&G sampled due to the cost of ship time. However, the HRM program manager (S. Pegau) has requested additional funds to support aerial surveys during spring in order to sample herring not associated with the main spawning event (i.e., non-spawners). We would essentially aerially survey for herring and once spotted, land and sample using a cast net from a raft. Similar methods have been employed by ADF&G in the past. Thus, we feel this is a viable option to obtain samples from non-spawning individuals during spring.

2. As described in the Procedural and Scientific Methods section of the original proposal, fish will be measured for length (mm) and wet weight (g). Ovaries will be dissected from the body and a gonadosomatic index (GSI) will be developed by weighing the gonad separately where GSI = (ovary weight/whole wet weight)*100. Thus, we are planning to measure gonad size and estimate a GSI, specifically for the reason the Panel notes, which is to allow for estimation of size-at-maturity.

3. Specific reference was made in the original proposal regarding previous work supported by EVOSTC and conducted by NOAA staff on age at first spawning by female Pacific herring. As described in the original proposal, "Heintz and Vollenweider (NOAA-Auke Bay Labs) conducted preliminary studies of Pacific herring age at maturity during the current HRM program (2012-2016). Their work included a lab study of southeast Alaska herring to determine the seasonal timing where immature, recruit, and repeat spawners could be identified based on ovary histology to determine maturation. This worked confirmed that histology is an accurate method for discerning these maturation stages. Heintz and Vollenweider also conducted a summer only field study of PWS herring coupling ovary maturation indices with scale growth patterns following similar work conducted on Norwegian Spring-Spawn herring (Engelhard et al. 2003, Engelhard and Heino 2004a, 2005). The Norwegian studies are based on predictable changes in the width and microstructure of the annual scale growth layer relative to the maturation of gonads for this stock (Engelhard et al. 2003). For example, as herring mature and trade-off somatic growth for reproductive investment, a corresponding change in scale growth

occurs where spawning individuals have smaller associated scale growth layers. Finally, Heintz and Vollenweider collected scales only from fish during one spring to detect age at first spawn and also examined ADF&G's long-term (1985-2013) herring scale data regarding annuli widths for age cohorts. Results from these studies were equivocal - scale growth did not appear to be a strong predictor of reproductive investment or age at maturity. However, several aspects of their work warrant further investigation by new studies. First, the initial timing study to discern various maturation states was conducted on laboratory fish from southeast Alaska. Secondly, analyses of coupled maturation state and scale growth were not completed for age-specific cohorts at an optimal time determined for wild PWS fish. Finally, these previous studies used relatively small sample sizes (lab study: n = 15/month, n = 100 fish/age group for coupled histology and scale growth)."

Studies by Heintz and Vollenweider should be considered preliminary work, upon which this proposal builds. Importantly, their worked revealed that histology is an accurate method for discerning maturation stages. Therefore, this eliminates the need to consider other measures of herring and clupeid maturation (see also AUTHOR RESPONSE 4). Thus, this proposal should be viewed as an opportunity to definitively assess the seasonal timing that best determines maturation states, i.e., both post and maturing ovarian follicles, among wild PWS female herring and to rigorously assess the coupled histology and scale growth issue with sample sizes much larger (i.e., 345 fish/year/age cohort) than that accomplished by Heintz and Vollenweider.

4. The Panel is correct in that there are other publications and criteria used for assessing herring maturation. For example, Hay (1985) is an excellent review of Pacific herring reproduction. However, we have chosen to use histology to discern maturation as Heintz and Vollenweider have shown this to be a reliable and accurate technique for this purpose. Thus, the study does not consider other methods.

5. This study is proposed for 5 years to explicitly address inter-annual variability in age at maturity, something Heintz and Vollenweider never addressed in their preliminary work. One of the more compelling results from the literature is that age at maturity among herring can vary based on density or oceanographic conditions (Engelhard and Heino 2004a, b). Since EVOSTC support is a unique opportunity to assess longer-term changes in age at maturity over 5 years among PWS herring, we would like to explore this research objective regarding inter-annual variability, as it would advance the proposed research from simply being a technique validation study to using the technique to understand ecological dynamics in the PWS herring system.

AUTHOR RESPONSES TO S. DRESSEL COMMENTS 8/22/2016

Gorman – Herring Maturity

I'm excited to see this study on maturity and will be really interested to see the scale and histology comparison work.

In the background, the proposal states that maturity is an ASA model inputs. Currently, I believe the maturity function is actually an output estimate (see AUTHOR RESPONSE 6).

The proposal identifies how many fish of each age need to be collected at each sampling time, but never addresses how many fish need to be captured overall or how they will determine whether 345 are collected from each age, as age determination is not determined at the time of sampling. This will be critical in order to ensure that they will be able to achieve their objectives. I expect this may need to be accomplished by converting to length, but length distributions of different cohorts overlap considerably. As such, it may also be necessary to acknowledge in the proposal that sample sizes may not be met (see AUTHOR RESPONSE 7).

I'm concerned that there aren't any citable results from the Heinz and Vollenweider study and that no conclusions from that study are able to be used as a basis for this new study's design and direction. Despite previous funding, the new study doesn't appear to be able to use results gained from the past funding. If there is a final report or manuscript where the methods and results are reported, it would be extremely valuable. Any results from that study are inherently dependent upon the methods used. Without knowing what those were, the EVOSTC will be required to take our word for any conclusions and provide new funding without knowing what happened with previous funding (see AUTHOR RESPONSE 8).

In Hypothesis 1, I expect that "accurate" should be changed to "precise" since bias won't be able to be measured (see AUTHOR RESPONSE 9).

It appears that the proposal is assuming that age-6 fish are 100% mature based on the model output (stated in the Data Analysis section with no reference). However other models in the state estimate that not all age-6 fish are mature. Because the goal of the study is to investigate whether the current model estimates of maturity match empirical estimates, I would tend to also include age-6. If funding is too limited to incorporate another cohort, it would be possible to say that sampling is limited to ages 3-5 because those are the most likely to be partially mature and because those are the most likely to have measurable differences in scale growth, and then openly acknowledge that 100% maturity for age-6 is assumed (see AUTHOR RESPONSE 10).

If there are no results from Heinz and Vollenweider, what dataset is the power analysis based upon? This should be included in the methods (see AUTHOR RESPONSE 11).

AUTHOR RESPONSES

6. In conversation with S. Pegau, for PWS Herring ASA Model the maturity function is a model input, not output like it is in other areas of the State.

7. This is an important point that absolutely should have been better clarified in the original and revised versions of the proposal. I had already submitted the revised proposal when this issue was discussed with S. Dressel via phone on 8/18/2016, and at that time realized these details were lacking from the proposal. I have added these collection details to a second revision of the proposal under Procedural and Scientific Methods.

8. This has been a challenging aspect of pulling this study together. Although it is true that no formal reports are available on previous herring age at maturity work to cite in this proposal, I did discuss at length with J. Vollenweider the results of the past work and received personal communications that have been cited in this proposal.

9. Accurate has been changed to precise.

10. Text has been added to include the issue that age 6+ are assumed to be fully mature. The work will address this issue to some degree because if we find that age 5+ fish are 100% mature, we will be more confident that this is also true for age 6+ fish.

11. The power analysis is not based on a dataset, it is a one-tailed power analysis for single sample proportions. We have used this approach to understand the sample sizes and associated power needed to detect anywhere from a 5-20% reduction in the proportion of in the null proportion of spawners at a 0.05 significance level. The take home message is that with the sample sizes we can afford, we are likely only to be able to detect at least a 10% reduction in proportion of spawners. This information is found under Data Analysis and Statistical Methods.

Literature Cited

Engelhard, G. H., U. Dieckmann, and O. R. Godo. 2003. Age at maturation predicted from routine scale measurements in Norwegian spring-spawning herring (Clupea harengus) using discriminant and neural network analyses. Ices Journal of Marine Science 60:304-313.

Engelhard, G. H., and M. Heino. 2004a. Maturity changes in Norwegian spring-spawning herring before, during, and after a major population collapse. Fisheries Research 66:299-310.

Engelhard, G. H., and M. Heino. 2004b. Maturity changes in Norwegian spring-spawning herring *Clupea harengus*: compensatory or evolutionary responses? Marine Ecology Progress Series 272:245-256.

Engelhard, G. H., and M. Heino. 2005. Scale analysis suggests frequent skipping of the second reproductive season in Atlantic herring. Biology Letters 1:172-175.

Hay, D. E. 1985. Reproductive biology of Pacific herring (Clupea harnangus pallasi). Canadian Journal of Fisheries and Aquatic Sciences 42:111-126.

Appendix C

EVOSTC FY17-FY21 INVITATION FOR PROPOSALS
PROGRAM PROJECT PROPOSAL SUMMARY PAGE

Project Title

Herring Research and Monitoring Program: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (*Clupea pallasii*) in Prince William Sound, Alaska

Primary Investigator(s) and Affiliation(s)

Kristen B. Gorman, Prince William Sound Science Center (PWSSC), P.O. Box 705, Cordova, AK 99574

Date Proposal Submitted

August 12, 2016

Project Abstract

To address the lack of recovery of Pacific herring (*Clupea pallasii*) in Prince William Sound (PWS), Alaska, research by the Herring Research and Monitoring (HRM) Program has been focused on improving predictive models of PWS herring stocks through observations and research. To this end, the goal of the project described here is ***to improve the HRM program's updated (Bayesian) PWS herring Age-Structured Assessment model's ability to more accurately predict the total population's biomass by empirically assessing reproductive maturity among age cohorts***. Currently, the age at maturity function in the ASA model is not based on empirical data. An improved understanding of age at maturity will allow for more accurate estimates of the total population biomass, which is central to the management of this fishery. The objectives of the studies proposed here are fourfold: 1) assess the seasonal timing (spring, summer, and fall) that allows for accurate determination of both previously spawned and maturing female herring based on ovary histology to determine maturation states; 2) couple histology results with annual scale growth information at the individual level, within specific age cohorts across seasons, to understand if scale growth patterns reflect reproductive investment; 3) assess whether annual scale growth patterns can be used to infer age at maturity at the individual level across age cohorts given results from objectives 1 and 2, and 4) assess inter-annual variability in age at maturity based on coupled histology and scale growth over a five-year period by focused, increased sampling during the optimal seasonal period given results from objectives 1-3. The proposed approach will advance preliminary worked conducted previously by HRM investigators by testing the appropriate sampling time of wild PWS herring for ovary characteristics, as opposed to lab-based studies, and increasing sample sizes for more powerful analyses. Studies proposed here address a key demographic parameter. Therefore, this research will not only contribute to the management of PWS herring, but also to a more general understanding of herring demography. As world-wide herring populations encounter more variable environmental conditions in the future, basic knowledge of herring demography and ecology will be invaluable.

EVOSTC Funding Requested *(must include 9% GA)*

FY17	FY18	FY19	FY20	FY21	TOTAL
$170.0	172.0	165.1	169.6	173.3	850.0

Non-EVOSTC Funding Available

FY17	FY18	FY19	FY20	FY21	TOTAL
NA	NA	NA	NA	NA	NA

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Please refer to the Invitation for the specific proposal requirements for each Focus Area. The information requested in this form is in addition to the information requested in each Focus Area and by the Invitation.

1. Executive Summary
Identify the hypotheses the project is designed to address. Describe the background and history of the problem. Include a scientific literature review that covers the most significant previous work history related to the project. Please provide a summary of the project including key hypotheses and overall goals.

Project Background

Forage fishes, known as abundant and schooling species, are critical marine ecosystem components for their role in energy transfer from lower to higher trophic levels including larger fishes, seabirds and marine mammals (Springer & Speckman 1997). Where one or a few forage fish species tend to be the principal conveyors of energy through an ecosystem, often termed *wasp-waist* (Rice 1995, Cury et al. 2000, Hunt & McKinnell 2006), these populations can often fluctuate greatly in size and even stabilize at higher or lower abundance depending on the form of ecological interactions at play - from bottom-up and top-down forcing, to interspecific and density-dependent competition (Bakun 2006).

Pacific herring (*Clupea pallasii*, hereafter herring) of Prince William Sound (PWS), Alaska, are a regional example of a *wasp-waist* forage fish system that has undergone dramatic changes in population size over the last 35 years. During the 1980's, the PWS herring population sustained a commercial fishery with important subsistence and economic benefit to regional communities. Based on Alaska Department of Fish & Game's (ADF&G) Age-Structured Assessment (ASA) model at this time, biomass of PWS herring was ~60,000-110,000 metric tons (mt). Following the *Exxon Valdez* oil spill in March 1989, the PWS herring fishery remained active, but the population began a precipitous decline falling to ~20,000 mt by 1993. Herring of PWS rebounded, but then collapsed again below ~20,000 mt in 1998 following a short period of commercial harvest. Biomass of PWS herring has remained at ~20,000 mt since 1998 and continues to remain below a level that would allow a commercial catch (Pegau et al. 2013, Pegau et al. 2014).

Factors underlying the initial decline in PWS herring biomass during the early 1990's and the continued lack of recovery are not well understood (e.g., Norcross et al. 2001, Thorne & Thomas 2008, Pearson et al. 2012). To enhance our understanding of the demography, ecology, and population dynamics of PWS herring, the *Exxon Valdez* Oil Spill Trustee Council (EVOSTC) supported an integrated herring restoration plan between 2009-2011 initially known as the Prince William Sound Herring Survey, which was focused on 1) identification of juvenile rearing bays, 2) understanding factors limiting herring recruitment such as abiotic and biotic environmental conditions, disease and predation, and 3) enhancing knowledge on spatial and temporal monitoring for future studies (Pegau et al. 2013). This initial program has continued over the past five years (2012-2016) as the PWS Herring Research and Monitoring (HRM) Program. Currently, the program's overall goal is focused on improving predictive models of herring stocks through monitoring and research with the following objectives: 1) provide information to improve input to, or test assumptions within, ADF&G's Age-Structure-Analysis (ASA) model, 2) inform the required synthesis effort, 3) address assumptions in current measurements, and 4) develop new approaches to monitoring (Pegau et al. 2014).

Looking forward to the next five-year research plan for the PWS HRM program, the overall goal remains unchanged in that investigators plan to build off previous studies and continue to *improve predictive models of herring stocks through observations and research*. During the last five years, the ASA model was updated in a Bayesian framework, which allows for estimation of uncertainty in model output (Pegau et al. 2014, Muradian 2015). One of the key ASA model inputs is an age at reproductive maturity function, i.e., the age at which herring spawn for the first time, which is used to adjust estimates of the total population biomass based on the age composition of the spawning population. Validating the estimated proportions of first-spawn (primiparous) individuals in each age class is the key objective of the study proposed here as the current ASA model's age at maturity function (Table 1) is not currently based on empirical data, but simply uses values that best fit the model. Importantly, validating PWS herring age at maturity may improve the predictive capabilities of the current ASA model in terms of the overall population biomass estimates.

Table 1. Current age at maturity function used in Bayesian ASA model for Pacific herring in Prince William Sound, Alaska.

Age	*% Spawning*	*% Spawning*	*% Brood Year 1st Spawn*
	1980-1996	*1997-Present*	*1997-Present*
3	27	48	48
4	89	75	27
5	100	100	25

Age at reproductive maturity is a key demographic parameter, which explains its inclusion in stock assessment models such as the ASA. At the individual level, age at maturity can shape overall lifetime reproductive success (Stearns 1992, Bernardo 1993), and therefore, contribute to stock productivity. There is some evidence that age at maturity might vary with population size. For example, Engelhard and Heino (2004a) showed that age and length at 50% maturity of Norwegian spring-spawning herring was reduced (i.e., age) and increased (i.e., length), respectively, during a period of low stock abundance in comparison with periods before and after the population collapse. The selective factors that likely contributed to this phenomenon include 1) reduced intraspecific competition for food during low abundance that resulted in enhanced growth and early onset of maturity or 2) early reproducing fish were selected for by fishing pressure - the former appears to be a more likely explanation (Engelhard & Heino 2004b).

Within the context of Pacific herring, it is generally understood that age at maturity increases with latitude from about age 2 off California, to age 4-5 in the Bering Sea, western Alaska (Barton & Wespestad 1980, Hay 1985). Given this regional variability in age at maturity, it is unclear whether the proportions of fish spawning for the first time incorporated by the PWS ASA model are valid (Table 1). Heintz and Vollenweider (NOAA-Auke Bay Labs) conducted preliminary studies of Pacific herring age at maturity during the current HRM program (2012-2016). Their work included a lab study of southeast Alaska herring to determine the seasonal timing where immature, recruit, and repeat spawners could be identified based on ovary histology to determine maturation. This worked confirmed that histology is an accurate method for discerning these maturation stages (J. Vollenweider pers. comm.). Heintz and Vollenweider also conducted a summer only field study of PWS herring coupling ovary maturation indices with scale growth patterns following similar work conducted on Norwegian Spring-Spawn herring (Engelhard et al. 2003, Engelhard & Heino 2004a, 2005). The Norwegian studies are based on predictable changes in the width and microstructure of the annual scale growth layer relative to the maturation of gonads for this stock (Engelhard et al. 2003). For example, as herring mature and trade-off somatic growth for reproductive investment, a corresponding change in scale growth occurs where spawning individuals have smaller associated scale growth layers. Finally, Heintz and Vollenweider collected scales only from fish during one spring to detect age at first spawn and also examined ADF&G's long-term (1985-2013) herring scale data regarding annuli widths for age cohorts. Results from these studies were equivocal - scale growth did not appear to be a strong predictor of reproductive investment or age at maturity (Heintz and Vollenweider AMSS 2016 Poster). However, several aspects of their work warrant further investigation by new studies. First, the initial timing study to discern various maturation states was conducted on laboratory fish from southeast Alaska. Secondly, analyses of coupled maturation state and scale growth were not completed for age-specific cohorts at an optimal time determined for wild PWS fish. Finally, these previous studies used relatively small sample sizes (lab study: n = 15/month, n = 100 fish/age group for coupled histology and scale growth).

Here, studies are proposed to build from previous work by Heintz and Vollenweider. Proposed research will focus on adult female herring caught in the wild from PWS exclusively to determine the seasonal timing (spring, summer, fall) that allows for accurate determination of previously spawned and maturing female herring based on ovary histology. Studies will begin by first considering coupled maturation states and scale growth for age-specific cohorts, in addition to increasing sample sizes of females processed for both ovary maturation and scale growth patterns, particularly in the last three years of the study (n = 345 per age class/year). Finally, research will be conducted over the entire five-year period to assess inter-annual variability in age at maturity, something Heintz and Vollenweider never addressed yet has been shown to be a key attribute associated with herring population changes (Engelhard & Heino 2004a, b).

Overall HRM Program and Project-Specific Goals
The overall goal of the proposed Herring Research and Monitoring Program (2017-2021) is *to improve predictive models of PWS herring stocks through observations and research*. To this end, the goal of the project described here is ***to improve the Bayesian PWS herring Age-Structured Assessment model's ability to more accurately predict the total population's biomass by empirically assessing reproductive maturity among age cohorts***.

Key Hypotheses
H1 (NULL). Precise determination of previously spawned and maturing female herring (age 3-5), based on ovary histology to determine maturation states, is similar across seasons (spring, summer, fall).

Because there is limited previous work, we don't have any *a priori* predictions and are therefore testing the null hypothesis. This proposal assumes that age 6+ fish are 100% mature and therefore are not considering in the sampling design.

H2. Maturation status, within a given age cohort (3-5), will correspond to scale growth patterns where spawned females based on ovary status will show a corresponding reduction in the width of the annual scale growth layer for that year as more energy is invested into reproduction and away from somatic growth (see Table 2 for expected relationships for age 4+ females).

Table 2. Expected summer growth of scale layer based on spawning history (example from age 4+ females).

Summer Growth Year	Non-spawner (age 4+)	Spawner (age 4+)
Year 4	Larger	Smaller

H3. Annual scale growth patterns can be used to infer age at maturity at the individual level across age cohorts (age 3+-5+).

Appendix C

a) Age 3+ females are all assumed to be either immature or primiparous. Primiparous age 3+ females will show no evidence of post-ovulatory follicles and will have a smaller year 3 summer scale growth layer in comparison with immature age 3+ fish (Table 3).

Table 3. Expected summer growth of scale layers based on spawning history among age 3+ herring.

Summer Growth Year	Age 3+, Immature	Age 3+, Primiparous
Year 1	Larger	Larger
Year 2	Larger	Larger
Year 3	Larger	Smaller

b) Age 4+ females will be a mix of immature, primiparous and second year spawners. Age 4+ females will differ in the widths of their year 3-4 summer scale growth layers where immature females will have larger year 3 and 4 summer scale growth layers than primiparous or second-year spawners; primiparous females will have smaller year 4 summer scale layers than immature fish, but larger year 3 summer scale growth layers than second-year spawners; second-year spawners will have smaller year 3 summer scale growth layers than immature and primiparous fish and smaller year 4 summer scale growth layers than immature fish, but year 4 summer scale growth layer will not be different than primiparous females (Table 4).

Table 4. Expected summer growth of scale layers based on spawning history among age 4+ herring.

Summer Growth Year	Age 4+, Immature	Age 4+, Primiparous	Age 4+, 2nd Year Spawner
Year 1	Larger	Larger	Larger
Year 2	Larger	Larger	Larger
Year 3	Larger	Larger	Smaller
Year 4	Larger	Smaller	Smaller

c) Age 5+ females will be a mix of primiparous, second and third year spawners. Age 5+ females will differ in the widths of their year 3-5 summer scale growth layers where primiparous fish will have larger year 4 summer scale growth layers than previously spawned females; previously spawned females will have smaller year 3-5 summer scale growth layers depending on if they are second or third year spawners (Table 5).

Table 5. Expected summer growth of scale layers based on spawning history among age 5+ herring.

Summer Growth Year	Age 5+, Primiparous	Age 5+, 2nd Year Spawner	Age 5+, 3rd Year Spawner
Year 1	Larger	Larger	Larger
Year 2	Larger	Larger	Larger
Year 3	Larger	Larger	Smaller
Year 4	Larger	Smaller	Smaller
Year 5	Smaller	Smaller	Smaller

H4. Mature (primiparous, second and third year spawners) female herring will have a higher gonadosomatic index, be heavier and longer than immature female herring for a given age cohort. Similarly, a greater proportion of age 3+ female herring will be primiparous following greater food supply or enhanced environmental conditions during the summer of year 3. A greater proportion of age 4+ female herring will be primiparous following lower food supply during the summer of year 4.

Appendix C

2. Relevance to the Invitation for Proposals
Discuss how the project addresses the projects of interest listed in the Invitation and the overall Program goals and objectives. Describe the results you expect to achieve during the project, the benefits of success as they relate to the topic under which the proposal was submitted, and the potential recipients of these benefits.

The overall goal of the Herring Research and Monitoring program is to *improve predictive models of herring stocks through observations and research*. This is consistent with the overall program goal described in the request for proposals (FY17-21 RFP) and the direction provide by the EVOSTC when the enhanced monitoring option of the Integrated Herring Restoration Program was chosen. By working to improve the predictive models of PWS herring stock biomass, it is anticipated that the data will be used to provide a tool for fisheries managers to make more informed decisions. The studies outlined here directly address the area of interest identified in the FY17-21 RFP (draft 11.02.15), #9 - A study to estimate and corroborate herring age at maturity with ASA model estimates. Further, by conducting this work over a five-year period to assess inter-annual variability in age at maturity, the studies proposed here also addresses EVOSTC's interest in retrospective analyses evaluating environmental effects (i.e., physical and biological oceanographic factors) that might be influencing PWS herring populations (#7).

Results from these studies are expected to contribute to the precision of the ASA model for estimating total PWS herring biomass, in addition to increasing scientific knowledge about herring demography and ecology. Potential recipients of the knowledge gained by these studies primarily include herring fisheries managers and commercial fisherman, as well other herring scientists and the public.

Appendix C

3. Project Personnel

The CV's of all principal investigators and other senior personnel involved in the proposal must be provided. Each resume is limited to two consecutively numbered pages and must include the following information:

- A list of professional and academic credentials, mailing address, and other contact information.
- A list of your most recent publications most closely related to the proposed project and up to five others.
- A list of all persons (including their organizational affiliations) in alphabetical order with whom you have collaborated on a project or publication within the last four years.

KRISTEN B. GORMAN

Curriculum Vitae

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PROFESSIONAL APPOINTMENTS

Research Ecologist July 2014 – Present	Prince William Sound Science Center, Cordova, Alaska

EDUCATION

Ph.D. Sept 2008 – Jan 2015	Dept. of Biological Sciences, Simon Fraser University, Burnaby, BC and Polar Oceans Research Group, Palmer Station LTER-NSF, Antarctica. *Advisors*: Prof. T.D. Williams (SFU) and Dr. W.R. Fraser (Palmer LTER).
M.Sc. Jan 2002 – Apr 2005	Dept. of Biological Sciences, Simon Fraser University, Burnaby, BC and Alaska Science Center – USGS, Anchorage, Alaska. *Advisors*: Prof. T.D. Williams and Dr. D. Esler (SFU), Dr. P.L. Flint (AK-USGS).
B.S. Sept 1992 – May 1996	Dept. of Biology, Dickinson College, Carlisle, PA. *Advisor*: Prof. C. Loeffler.

CURRENT RELEVANT ACTIVITIES

PI. *Comparative Performance in Migration and Reproduction among Wild and Hatchery Pink Salmon (Oncorhynchus gorbuscha) in Prince William Sound, Alaska using Stable Isotope Analysis.* PWSSC project funded by National Fish and Wildlife Foundation, 2016-2017.

PI. *Juvenile Herring Condition Monitoring*. PWSSC project funded by Exxon Valdez Oil Spill Trustee Council, 2014-2016.

PI. *Hatchery-Wild Salmon Stream Interactions*. PWSSC project funded by Alaska Department of Fish & Game – Hatchery Research Program, 2014–2018.

RECENT RELATED PROFESSIONAL EXPERIENCE

PI. *Juvenile Herring Condition Monitoring, Intensives.* PWSSC project funded by Exxon Valdez Oil Spill Trustee Council, 2014.

co-PI *Assessing Breeding Population Genetic Structure of Adélie Penguins (Pygoscelis adeliae) occurring West of the Antarctic Peninsula*. Simon Fraser U project funded by Antarctic Science Bursary, 2012.

co-PI. *Divergent Population Response by Pygoscelis Penguins to Rapid Climate Warming: Nutritional and Physiological Stress Mechanisms.* Simon Fraser U project funded by American Museum of Natural History, 2010; The American Ornithologists' Union, 2009; The Explorers Club, 2009.

Appendix C

SELECTED PUBLICATIONS AND REPORTS (10 of 16, *indicates most closely related)

Knudsen, E., M. Buckhorn, **K. Gorman**, D. Crowther, K. Froning, M. Roberts, L. Marcello, B. Adams, and V. O'Connell, and D. Bernard. 2015. *Interactions of wild and hatchery pink salmon and chum salmon in Prince William Sound and Southeast Alaska*. Prince William Sound Science Center Final Report 2013 and 2014 to Alaska Department of Fish & Game, Contract IHP-13-013. *Work conducted throughout Prince William Sound, Alaska.

Gorman, K.B. 2015. Integrative studies of Southern Ocean food-webs and *Pygoscelis* penguin demography: mechanisms of population response to environmental change. Ph.D. Thesis. Simon Fraser University, Burnaby, British Columbia, Canada. 337 pp. *Includes work on *Pleuragramma antarcticum* a Southern Ocean forage fish similar to Pacific herring.

Gorman, K.B., T.D. Williams, and W.R. Fraser. 2014. Ecological sexual dimorphism and environmental variability within a community of Antarctic penguins (genus *Pygoscelis*). *PLoS ONE* 9(3): e90081.

Schofield, O., H. Ducklow, K. Bernard, S. Doney, D. Patterson-Fraser, **K. Gorman**, D. Martinson, M. Meredith, G. Saba, S. Stammerjohn, D. Steinberg, and W. Fraser. 2013. Penguin biogeography along the West Antarctic Peninsula: Testing the canyon hypothesis with Palmer LTER observations. *Oceanography* 26(3):78-80.

Crossin, G.T., P.N. Trathan, R.A. Phillips, **K.B. Gorman,** A. Dawson, K.Q. Sakamoto, and T.D. Williams. 2012. Variation in baseline corticosterone predicts foraging behaviour and parental care in macaroni penguins. *The American Naturalist* 180(1):E31-E41.

Bestelmeyer, B.T., A.M. Ellison, W.R. Fraser, **K.B. Gorman**, S.J. Holbrook, C.M. Laney, M.D. Ohman, D.P.C. Peters, F.C. Pillsbury, A. Rassweiler, R. Schmitt, and S. Sharma. 2011. Analysis of abrupt transitions in ecological systems. *Ecosphere* 2(12):art129.

Gorman, K.B., D. Esler, R.L. Walzem, and T.D. Williams. 2009. Plasma yolk precursor dynamics during egg production by female Greater Scaup *(Aythya marila*): characterization and indices of reproductive state. *Physiological and Biochemical Zoology* 82(4):372-381. *Work on egg production in waterfowl.

Gorman, K.B., D. Esler, P.L. Flint, and T.D. Williams. 2008. Nutrient reserve dynamics during egg production by female Greater Scaup (*Aythya marila*): relationships with timing of reproduction. *Auk* 125(2):384-394. *Work on egg production in waterfowl.

Gorman, K.B., P.L. Flint, D. Esler, and T.D. Williams. 2007. Ovarian follicle dynamics of female Greater Scaup during egg production. *Journal of Field Ornithology* 78(1):64-73. *Work on egg production in waterfowl.

Gorman, K.B. and T.D. Williams. 2005. Correlated evolution of maternally derived yolk testosterone and early developmental traits in passerine birds. *Biology Letters* 1(4):461-464.

Service to the Scientific Community

Peer-review of manuscripts for *Biology Letters* (4), *Journal of Animal Ecology* (1), *Journal of Avian Biology* (1), *Marine Ecology Progress Series* (4), *Physiological and Biochemical Zoology* (1), *Polar Biology* (3), *The American Naturalist* (1), *Waterbirds* (1).

Collaborators (last 48 months)

S Adlard (BAS), K Bernard (OSU), MA Bishop (PWSSC), G Crossin (Dalhousie U), A Dawson (NERC), S Doney (Woods Hole), A Dawson (C. Ecol Hydrol, NERC), H Ducklow (Lamont-Doherty), D Esler (Simon Fraser U), M Fowler (USGS), W Fraser (Polar Oceans Res Group), R Heintz (NOAA), P Hershberger (USGS), E Knudsen (PWSSC), D Martinson (Lamont-Doherty), M Meredith (Brit Ant Surv), S Pegau (PWSSC), R Phillips (BAS), P Rand (USGS), K Ruck (VIMS), G Saba (Rutgers), K Sage (USGS), K Sakamoto (Hokkaido U), O Schofield (Rutgers U), F. Sewall (NOAA), S Sonsthagen (USGS), S Stammerjohn (CU Boulder), D Steinberg (VIMS), S Talbot (USGS), P Trathan (BAS), T Williams (Simon Fraser U).

4. Project Design

A. Objectives

List the objectives of the proposed research and briefly state why the intended research is important. If your proposed project builds on recent work, provide detail on why the data set needs to be continued and whether any changes are proposed. If the proposed project is for new work, explain why the new data is needed. Describe the anticipated final product.

B. Procedural and Scientific Methods

For each objective listed in A. above, identify the specific methods that will be used to meet the objective. In describing the methodologies for collection and analysis, identify measurements to be made and the anticipated precision and accuracy of each measurement and describe the sampling equipment in a manner that permits an assessment of the anticipated raw-data quality.

If applicable, discuss alternative methodologies considered, and explain why the proposed methods were chosen. In addition, projects that will involve the lethal collection of birds or mammals must comply with the EVOSTC's policy on collections, available on our website www.evostc.state.ak.us

C. Data Analysis and Statistical Methods

Describe the process for analyzing data. Discuss the means by which the measurements to be taken could be compared with historical observations or with regions that are thought to have similar ecosystems. Describe the statistical power of the proposed sampling program for detecting a significant change in numbers. To the extent that the variation to be expected in the response variable(s) is known or can be approximated, proposals should demonstrate that the sample sizes and sampling times (for dynamic processes) are of sufficient power or robustness to adequately test the hypotheses. For environmental measurements, what is the measurement error associated with the devices and approaches to be used?

D. Description of Study Area

Where will the project be undertaken? Describe the study area, including, if applicable, decimally-coded latitude and longitude readings of sampling locations or the bounding coordinates of the sampling region (e.g., 60.8233, -147.1029, 60.4739, -147.7309 for the north, east, south and west bounding coordinates).

Objectives

The objectives of the proposed research follow:

1) Assess the seasonal timing (spring, summer, and fall) that allows for accurate determination of both previously spawned and maturing female herring based on ovary histology to determine maturation states

2) Couple histology results with annual scale growth information at the individual level, within specific age cohorts, to understand if scale growth patterns reflect reproductive investment.

3) Assess whether annual scale growth patterns can be used to infer age at maturity at the individual level across age cohorts given results from objectives 1 and 2.

4) Assess inter-annual variability in age at maturity based on coupled histology and scale growth over a five-year period by focused, increased sampling during the optimal seasonal period given results from objectives 1-3.

The research described here is important. The data produced through these studies will improve the Bayesian ASA model - a biologically meaningful age at maturity function will more precisely adjust estimates for the total PWS herring population biomass. The proposed work builds on previous work by HRM investigators regarding age at maturity of PWS herring. However, there are some clear differences from the past work. First, the proposed research will focus on fish caught in the wild from PWS exclusively to determine the seasonal timing that allows for accurate determination of previously spawned and maturing female herring based on ovary histology to determine maturation states, unlike previous work that focused on lab studies of Southeast Alaska herring only. The proposed research will first assess coupled maturation states and scale growth for age-specific cohorts and increase sample sizes of females processed for both ovary maturation and scale growth patterns in comparison with past work. Finally, the proposed study will be conducted over an entire five-year period to assess inter-annual variability in age at maturity, something not addressed by previous work.

The anticipated final products from this work will be a series of papers that address each of the main hypotheses outlined above, in addition to producing a revised age at maturity function for the Bayesian ASA model.

Procedural and Scientific Methods

Objective 1. This study will be conducted during the first two years of the five-year program. The main focus here is to resolve the time of year female fish can be collected where post-ovulatory follicles (POFs) are still visible from an earlier spawning event, in addition to evidence of newly developing follicles in preparation for the next spawning event.

Female fish will be collected at three times during the year – a) during spring (March/April) collections for age, sex and length (S. Moffitt, ADF&G) and adult herring acoustics (P. Rand, PWSSC). These collections will take advantage of existing ship time to complete the fieldwork. Aerial surveys will also be conducted during spring to identify fish outside the spawning population to sample via raft and cast net; b) during summer (late June) in association with a more limited aerial survey effort simply to identify schools of fish; and c) during fall (September/October) in association with Gulf Watch Alaska (GWA) forage fish surveys (M. Arimitsu and J. Piatt, USGS). There may also be the possibility of collecting fish in December as part of the GWA whale/forage fish survey (R. Heintz and J. Moran, NOAA). Thus, it is anticipated that there will be at least three collection periods including spring, summer and fall. Any additional sampling in winter would likely only be conducted in year 1. Females aged 3-5 will be targeted for collection mainly using trawl gear. Sample sizes follow: age 3+ (n = 115 fish/seasonal collection, total 345/year), age 4+ (n = 115/collection, 345/year), and age 5+ (n = 60 fish/collection, 120/year) resulting in a total of 870 fish collected in each of the first two years of the study. In order to reach the sample sizes required for histology and scale analysis of females, over collection of herring will be required and the immediate determination of sex and age in the field in order to target enough female fish per age cohort. Once collected, fish will be processed immediately aboard charter vessels. First, a scale will be removed for aging using a dissecting scope. Once age is determined, an individual fish between the ages of 3+ - 5+ will be further processed. All fish within these ages will be measured for length (mm) and wet weight (g). Gonads will be dissected from the body and a gonadosomatic index (GSI) will be developed by weighing the gonad separately where GSI = (ovary weight/whole wet weight)*100. For female herring, a small mid-section of ovary will be dissected and preserved in formalin for slide mounting and pathology analysis (H. Snyder, President and CEO, and J. Kramer, DVM, Histologistics, Worcester, MA) for discerning maturity states following criteria outlined by Brown-Peterson et al. (2011). Several additional scales from the lateral side of the body for both males and females will be collected and mounted on slides. These scales will be used to measure individual scale annuli of females only using imaging software by an ADF&G Cordova technician. By additionally collecting scales from males, we will archive these samples for any future analyses of male herring scale growth. It is entirely possible that it will be difficult to meet targeted sample sizes, as we do not know in advance what the age structure of fish schools are ahead of sampling.

It is expected that females collected during the spring spawn surveys will have evidence of developed follicles as part of the current spawning event. It is unclear whether POFs will be evident at this time or not. Some proportion of females collected during summer should have evidence of POFs from the prior spring spawning event, while others may not, particularly for age 3 fish. Whether developing follicles for the next spring's spawning event will be evident at this time is not known. Females collected during the early fall likely have the greatest potential to show both evidence of POFs from previous spawning the spring prior as well as developing follicles for the next spawning event. These collections are expected to help resolve the seasonal timing most optimal for understanding both the immediate spring season's spawning history and the future spring's spawning decisions of individuals.

Objective 2. This study will build from the first two years of data collected where ovary maturation characteristics will be compared with annual scale growth data at the individual level within age cohorts. The key to the success of this part of the project is to be able to compare scale growth patterns from individuals of the same age cohort that have differing ovary characteristics. For example, scale growth patterns of age 3+ females, caught in the fall, that have evidence of POFs and developing follicles will be compared with other age 3+ females that have no evidence of POFs and either developing or non-developing ovaries in preparation for the following spring spawning event. The prediction is that age 3+ females with POFs would have a smaller year 3 summer growth layer in comparison with age 3+ females with no POFs. This would confirm that scale growth patterns could help resolve age at reproductive maturity. This analysis will also be applied to age 4+ and 5+ females.

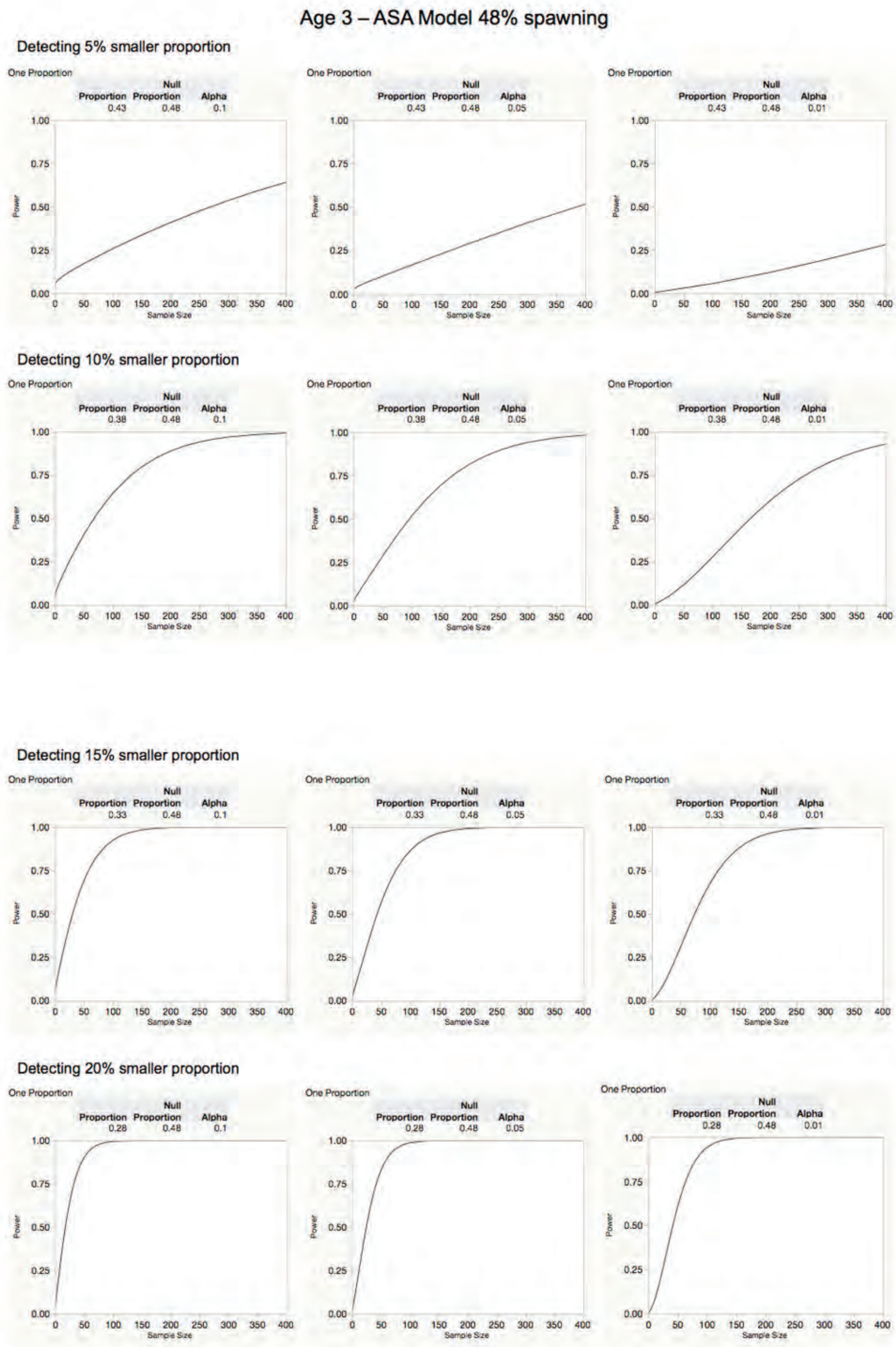
Objective 3. If it appears that ovary maturation does relate to scale growth (objectives 1 and 2), this information will be used to assess age at maturity at the individual level for fish across age cohorts. Scale growth criteria for age at maturation will be developed for each age class based on work conducted as part of objective 2 above. For example, for age class 3+, the difference in summer scale growth between immature and primiparous females for year 3 will be specifically quantified with associated confidence intervals, which then could be used to classify individuals of known reproductive state (discriminant function or similar analyses). These criteria will then be applied to year 3 summer scale growth for age 4+ and 5+ fish to discern if these fish spawned in year 3 or not. Such criteria will also be developed for age 4+ fish and then applied to age 5+ fish for year 4, as well as age 5 fish for year 5.

Objective 4. Once the optimal seasonal timing of sampling is determined by the previous studies during the first two years of the project, the follow three years will focus collections on this one time period and increase the sample sizes for age 3+ and 4+ fish only during this period. Therefore, for years 3-5, samples sizes for age 3+ and 4+ fish during one collection period only will be n = 345 each for a total of 690/year. Data will be collected in the field, a professional pathologist will determine maturation states, and scale growth will be measured using imaging software. Additionally for this study, environmental data collected by GWA researchers (R. Campbell, PWSSC) will be used to characterize the entire five years for temperature, salinity, chlorophyll *a*, and zooplankton abundances in order to characterize the environmental conditions that shape annual proportions of age at maturity and scale growth patterns.

Data Analysis and Statistical Methods

Appendix C

Regarding the sample sizes proposed, a one-tailed power analysis for single-sample proportions was conducted and revealed that a sample size of 115 would result in power 70-95 for detecting a 10–15% reduction, respectively, in the null proportion of spawners (Table 1) at an alpha-level of 0.05 (Fig. 1). Because age 5+ fish should all be spawning individuals, the sample size for this age class in the first two years of the study has been reduced to $n = 60$/sampling event.



Appendix C

Figure 1. One-tailed power analysis results for single-sample proportions using JMP software. The null proportion is the ASA model's percent of age 4+ spawning proportion. Tests explore power and sample size needed to detect 5-20% reduction in proportions at alpha-levels 0.1-0.01. A sample size of 115 was determined to result in power 70-95 for detecting a 10–15% reduction in proportion.

Statistical analyses will use traditional statistics such as regression or ANOVA in an information-theoretic context (AIC, Burnham & Anderson 2002) to explore questions of interest related to ovary characteristics, scale growth and environmental parameters. For example, ANOVA would be used to determine differences in scale growth between non-spawners and spawners for a given age class (objective 2), with model selection following an AIC framework including a null model. This would allow for weighted parameter estimation. For objective 4, multiple-regression would be used to consider best predictors of age at maturity including a suite of environmental variables. Again, model selection would follow an AIC framework to determine the most parsimonious model and weighted parameter estimates. This statistical approach is particularly well suited for observational studies such as the work described here.

Appendix C

Study Area

The study area will include all of PWS, Alaska (Fig. 2). The spring collections will take place at spawning sites, which have typically been located along the northern coastline in recent years between Valdez and Gravina. Spawning has been known to occur in the southern portion of the sound near Montague Island. Summer and fall collections will take place wherever fish are found based on aerial surveys or other information.

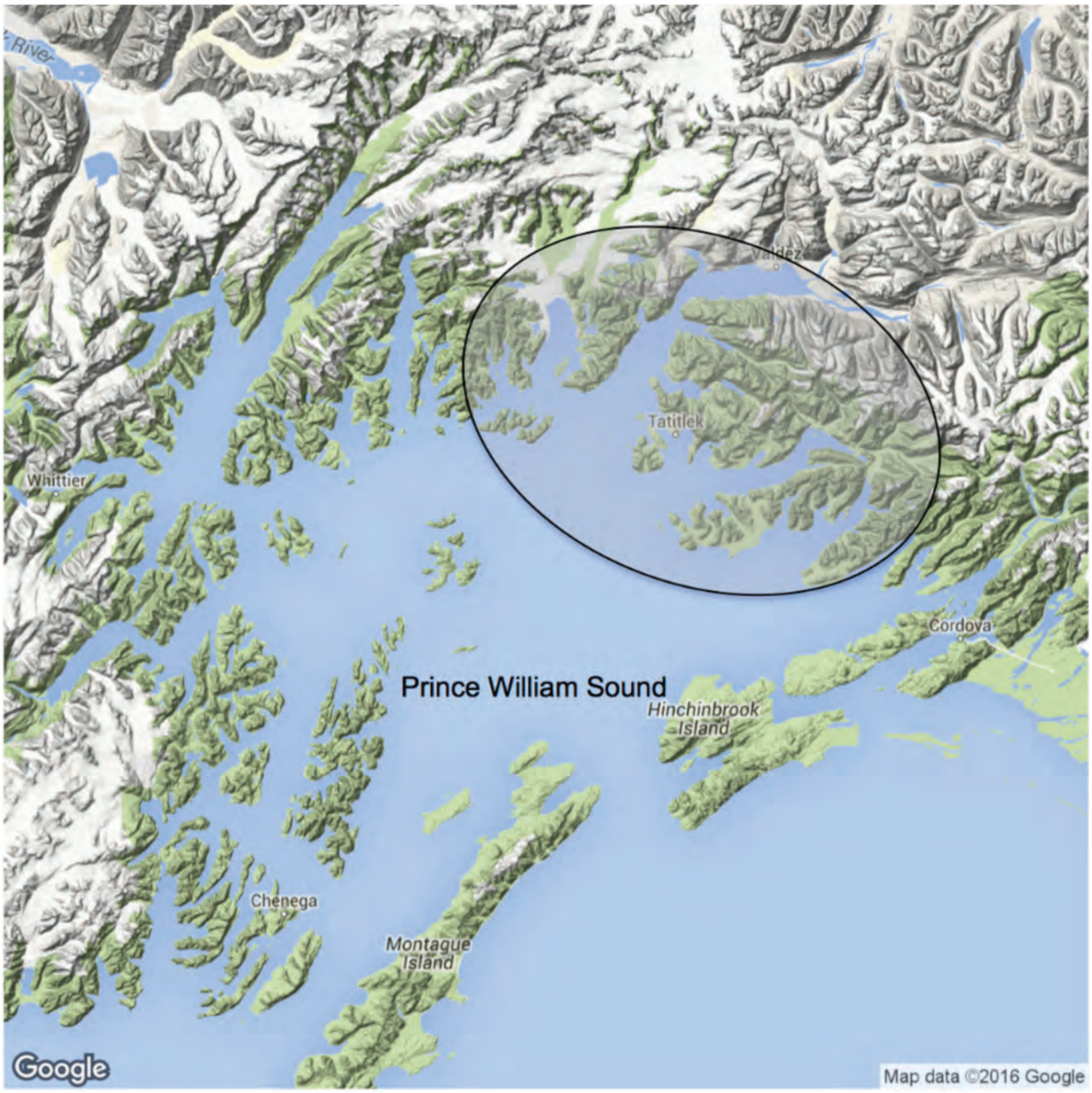


Figure 2. Map of PWS study area. Shaded circle shows northern location where herring have typically spawned in recent years.

5. Coordination and Collaboration

Within the Program

Provide a list and clearly describe the functional and operational relationships with the other program projects. This includes any coordination that has taken or will take place and what form the coordination will take (shared field sites or researchers, research platforms, sample collection, data management, equipment purchases, etc.).

With Other EVOSTC-funded Programs and Projects
Indicate how your proposed program relates to, complements or includes collaborative efforts with other proposed or existing programs or projects funded by the EVOSTC.

With Trustee or Management Agencies
Please discuss if there are any areas which may support EVOSTC trust or other agency work or which have received EVOSTC trust or other agency feedback or direction, including the contact name of the agency staff. Please include specific information as to how the subject area may assist EVOSTC trust or other agency work.

If the proposed project requires or includes collaboration with other agencies, organizations or scientists to accomplish the work, such arrangements should be fully explained and the names of agency or organization representatives involved in the project should be provided. If your proposal is in conflict with another project or program, note this and explain why.

With Native and Local Communities
Provide a detailed plan for any local and native community involvement in the project.

Coordination within the program
The proposed work will couple sampling during the first two years of the study with another HRM investigator coordinating the adult acoustics, as well as the aerial surveys and validation (P. Rand, PWSSC). Further, the data will be used in the Bayesian ASA modeling effort (T. Branch, UW).

Coordination with other EVOSTC-funded programs
The work described here plans to build off relationships established with GWA including maximizing the forage fish (M. Arimitsu and J. Piatt, USGS) and whale survey (R. Heintz, NOAA) efforts to collect samples for this study. Further, environmental data collected by other GWA investigators plan to be used in analyses (R. Campbell, PWSSC).

Coordination with Management Agencies
The scale aging and growth measurement work is collaborative with ADF&G (S. Moffitt, ADF&G Cordova). Initially, scales will be read in the first two years of the study by an ADF&G technician and this will allow for training a PWSSC technician at the same time who will then conducted the analyses in years 3-5.

6. Schedule
Program Milestones
Specify when critical program tasks will be completed. Reviewers will use this information in conjunction with annual program reports to assess whether the program is meeting its objectives and is suitable for continued funding.

Measurable Program Tasks
Specify, by each quarter of each fiscal year (February 1 – January 31), when critical program tasks will be completed.

Appendix C

Project Milestones

February 2017. Begin project.
December 2017. Complete Year 1 work.
December 2018. Complete Year 2 work. Objectives 1-3 completed.
December 2019. Complete Year 3 work.
December 2020. Complete Year 4 work.
December 2021. Complete Year 5 work. Objective 4 completed.
December 2022. Final report submitted.

Measureable Project Tasks

2017	
1nd Quarter (Jan – March)	Mar/Apr: Spring field collections, histology samples sent.
2rd Quarter (Apr – Jun)	Mar/Apr: Spring field collections, histology samples sent. Jun: Summer field collections, histology samples sent.
3th Quarter (Jul – Sept)	Aug: Proposal for 2018 submitted. Sept/Oct: Fall field collections, histology samples sent.
4th Quarter (Oct – Dec)	Sept/Oct: Fall field collections, histology samples sent. Nov: PI meeting. Dec: 2017 scale readings completed.
2018	
1nd Quarter (Jan – March)	Feb: 2017 Annual report completed and 2017 data submitted to AOOS portal. Mar/Apr: Spring field collections, histology samples sent.
2rd Quarter (Apr – Jun)	Mar/Apr: Spring field collections, histology samples sent. Jun: Summer field collections, histology samples sent.
3th Quarter (Jul – Sept)	Aug: Proposal for 2019 submitted. Sept/Oct: Fall field collections, histology samples sent.
4th Quarter (Oct – Dec)	Sept/Oct: Fall field collections, histology samples sent. Nov: PI meeting. Dec: 2018 scale readings completed.
2019	
1nd Quarter (Jan – March)	Feb: 2018 Annual report completed and 2018 data submitted to AOOS portal.
2rd Quarter (Apr – Jun)	
3th Quarter (Jul – Sept)	Optimal field collections (possibly), histology samples sent. Aug: Proposal for 2020 submitted.
4th Quarter (Oct – Dec)	Nov: PI meeting. Dec: 2019 scale readings completed.
2020	
1nd Quarter (Jan – March)	Feb: 2019 Annual report completed and 2019 data submitted to AOOS portal.
2rd Quarter (Apr – Jun)	

3rd Quarter (Jul – Sept)	Optimal field collections (possibly), histology samples sent. Aug: Proposal for 2021 submitted.
4th Quarter (Oct – Dec)	Nov: PI meeting. Dec: 2020 scale readings completed.
2021	
1nd Quarter (Jan – March)	Feb: 2020 Annual report completed and 2020 data submitted to AOOS portal.
2rd Quarter (Apr – Jun)	
3th Quarter (Jul – Sept)	Optimal field collections (possibly), histology samples sent.
4th Quarter (Oct – Dec)	Nov: PI meeting. Dec: 2020 scale readings completed.
2022	
1nd Quarter (Jan – March)	Feb: 2021 Annual report completed and 2020 data submitted to AOOS portal.
2rd Quarter (Apr – Jun)	
3th Quarter (Jul – Sept)	
4th Quarter (Oct – Dec)	Dec: Final report completed.

7. Budget

Budget Forms (Attached)

Please provide completed budget forms. Please note that the following items will not be considered for funding:

- Costs associated with international travel for meetings, symposia, or presentations.
- Costs associated with attendance at meetings, symposia, or presentations outside of those required to coordinate with project members.
- Costs associated with outreach or education efforts.

Sources of Additional Funding

Identify non-EVOSTC funds or in-kind contributions used as cost-share for the work in this proposal. List the amount of funds, the source of funds, and the purpose for which the funds will be used. Do not include funds that are not directly and specifically related to the work being proposed in this proposal.

Budget Narrative

Personnel Costs

Support is requested during each of the five years for two personnel, the PI - Kristen Gorman (6 months each year) and technician – Julia McMahon (3.5-4 months varying across the five years). A 3% cost of living increase was calculated for each year. Benefit amounts vary from 0.58 – 0.62 across the five years to reflect changes in heath care costs or additional benefit requirements of project staff (i.e., number of family plan members). *Overall amount requested $393,597*.

Appendix C

Staff	Year	Base Monthly Salary	Base Monthly Benefits	Total Monthly Salary and Benefits	Number of Months/year	Total Monthly Salary and Benefits
Gorman	2017	5720	0.58	9038	6	54228
McMahon	2017	3150	0.58	4977	3.5	17420
Gorman	2018	5892	0.60	9427	6	56562
McMahon	2018	3245	0.58	5126	3.5	17941
Gorman	2019	6069	0.60	9710	6	58260
McMahon	2019	3342	0.58	5281	4	21124
Gorman	2020	6251	0.60	10127	6	60762
McMahon	2020	3442	0.60	5508	4	22032
Gorman	2021	6439	0.62	10430	6	62580
McMahon	2021	3545	0.60	5672	4	22688
Overall Total						*393597*

Travel
Support is requested for the PI to attend yearly EVOSTC HRM PI meetings, $1,100/year for roundtrip airfare and two nights hotel and per diem. *Total $5100.*

Contractual
Support is requested for the following: PWSSC communications ($150/staff months/year); PWSSC printing and postage ($500/year); Histological analysis of collected ovaries ($15 for slide mounting and $10 for pathology reading/sample; Scale reading by ADF&G in years one and two ($6.02/scale, does not include 21% indirect cost for ADF&G); Vessel charter ($2500/day); Flight charter ($600/hour). *Total $192,468.*

Commodities
Support is requested for the following: A precision field balance to weigh fish and ovaries, requested only in year one ($600); Whirlpaks for storing fish each year ($300/1000 bags); Histology cassettes to store ovary samples each year ($100/1000 cassettes); Bottles to store cassettes in formalin each year ($250/100 bottles); Formalin each year ($800/40 gallons); Slides for mounting scales each year ($225/1440 slides); Vials for otolith preservation each year ($100/1000). *Total $9475*

Total Direct Costs
Total direct costs are estimated at *$599,540*.

Indirect Costs (IDC)
A 30% IDC of all direct costs is calculated for PWSSC in each year of the study. This is not calculated on equipment over $5000, which does not apply to this study. Total indirect costs are estimated at *$179,862*.

Total Direct and Indirect Costs
Total support requested *$779,787*.

Appendix C

8. Literature Cited

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

Budget Category:	Proposed FY 17	Proposed FY 18	Proposed FY 19	Proposed FY 20	Proposed FY 21	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$71.5	$74.3	$79.4	$82.6	$85.2	$393.0	
Travel	$1.1	$1.1	$1.1	$1.1	$1.1	$5.5	
Contractual	$45.0	$44.2	$34.2	$34.2	$34.2	$191.8	
Commodities	$2.4	$1.8	$1.8	$1.8	$1.8	$9.6	
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
Indirect Costs (*will vary by proposer*)	$36.0	$36.4	$35.0	$35.9	$36.7	$180.0	
SUBTOTAL	$156.0	$157.8	$151.5	$155.6	$159.0	$779.8	
General Administration (9% of	$14.0	$14.2	$13.6	$14.0	$14.3	$70.2	N/A
PROJECT TOTAL	$170.0	$172.0	$165.1	$169.6	$173.3	$850.0	
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	

COMMENTS:
This summary page provides an five-year overview of proposed project funding and actual cumulative spending. The column titled 'Actual Cumulative' must be updated each fiscal year as part of the annual reporting requirements. Provide information on the total amount actually spent for all completed years of the project. On the Project Annual Report Form, if any line item exceeds a 10% deviation from the originally-proposed amount; provide detail regarding the reason for the deviation.

FY17

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

NON-TRUSTEE AGENCY SUMMARY PAGE

Date Prepared: xx/xx/xxxx

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

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Kristen Gorman	Year 1	6.0	9.0	0.0	54.0
Julia McMahon	Year 1	3.5	5.0	0.0	17.5
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	14.0	0.0	
				Personnel Total	$71.5

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
PI Meeting 2017	0.5	1	3	0.2	1.1
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.1

FY17

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: xx/xx/xxxx

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

Contractual Costs: Description	Contract Sum
PWSSC Communications (network & phone) ($100/staff mo for network and $40/mo for phone + long distance)	1.5
PWSSC Postage and printing	0.5
Histology - slide mounting ($15/sample)	13.0
Histology - pathology reading ($10/sample)	8.7
ADF&G scale reading	5.2
Charter vessel (5 days at $2.5K/day)	12.5
Charter flights (4 hrs at $600/hr)	3.6
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$45.0

Commodities Costs: Description	Commodities Sum
Portable balance	0.6
Whirlpak bags	0.3
Histology cassettes	0.1
Cassette bottles	0.3
Formalin	0.8
Slides	0.2
Vials	0.1
Commodities Total	$2.4

FY17

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B CONTRACTUAL & COMMODITIES DETAIL

Date Prepared: xx/xx/xxxx

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

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
None			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency
Imaging software	1	ADF&G

FY18

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B
EQUIPMENT DETAIL

Date Prepared: xx/xx/xxxx

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

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Kristen Gorman	Year 2	6.0	9.4	0.0	56.4
Julia McMahon	Year 2	3.5	5.1	0.0	17.9
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	14.5	0.0	
				Personnel Total	$74.3

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
PI Meeting 2018	0.5	1	3	0.2	1.1
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.1

FY18

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: xx/xx/xxxx

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

Contractual Costs: Description	Contract Sum
PWSSC Communications (network & phone) ($100/staff mo for network and $40/mo for phone + long distance)	1.4
PWSSC Postage and printing	0.5
Histology - slide mounting ($15/sample)	13.0
Histology - pathology reading ($10/sample)	8.0
ADF&G scale reading	5.2
Charter vessel (5 days at $2.5K/day)	12.5
Charter flights (6 hrs at $600/hr)	3.6
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$44.2

Commodities Costs: Description	Commodities Sum
Whirlpak bags	0.3
Histology cassettes	0.1
Cassette bottles	0.3
Formalin	0.8
Slides	0.2
Vials	0.1
Commodities Total	$1.8

FY18

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B CONTRACTUAL & COMMODITIES DETAIL

Date Prepared: xx/xx/xxxx

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

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
None			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency
Imaging software	1	ADF&G

FY19

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B
EQUIPMENT DETAIL

Date Prepared: xx/xx/xxxx

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

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Kristen Gorman	Year 3	6.0	9.7		58.2
Julia McMahon	Year 3	4.0	5.3		21.2
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	15.0	0.0	
				Personnel Total	$79.4

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
PI Meeting 2019	0.5	1	3	0.2	1.1
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.1

FY19

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: xx/xx/xxxx

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

Contractual Costs: Description	Contract Sum
PWSSC Communications (network & phone) ($100/staff mo for network and $40/mo for phone + long distance)	1.5
PWSSC Postage and printing	0.5
Histology - slide mounting ($15/sample)	10.4
Histology - pathology reading ($10/sample)	6.9
Charter vessel (5 days at $2.5K/day)	12.5
Charter flights (4 hrs at $600/hr)	2.4
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$34.2

Commodities Costs: Description	Commodities Sum
Whirlpak bags	0.3
Histology cassettes	0.1
Cassette bottles	0.3
Formalin	0.8
Slides	0.2
Vials	0.1
Commodities Total	$1.8

FY19

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: xx/xx/xxxx

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

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
None			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptioı	Number of Units	Inventory Agency
Imaging software	1	ADF&G

FY20

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B
EQUIPMENT DETAIL

Date Prepared: xx/xx/xxxx

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

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Kristen Gorman	Year 4	6.0	10.1	0.0	60.6
Julia McMahon	Year 4	4.0	5.5	0.0	22.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	15.6	0.0	
				Personnel Total	$82.6

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
PI Meeting 2020	0.5	1	3	0.2	1.1
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.1

FY20

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: xx/xx/xxxx

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

Contractual Costs: Description	Contract Sum
PWSSC Communications (network & phone) ($100/staff mo for network and $40/mo for phone + long distance)	1.5
PWSSC Postage and printing	0.5
Histology - slide mounting ($15/sample)	10.4
Histology - pathology reading ($10/sample)	6.9
Charter vessel (5 days at $2.5K/day)	12.5
Charter flights (4 hrs at $600/hr)	2.4
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$34.2

Commodities Costs: Description	Commodities Sum
Whirlpak bags	0.3
Histology cassettes	0.1
Cassette bottles	0.3
Formalin	0.8
Slides	0.2
Vials	0.1
Commodities Total	$1.8

FY20

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B
CONTRACTUAL & COMMODITIES DETAIL

Date Prepared: xx/xx/xxxx

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

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
None			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency
Imaging software	1	ADFG

FY21

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B
EQUIPMENT DETAIL

Date Prepared: xx/xx/xxxx

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

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Kristen Gorman	Year 5	6.0	10.4	0.0	62.4
Julia McMahon	Year 5	4.0	5.7	0.0	22.8
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	16.1	0.0	
				Personnel Total	$85.2

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
PI Meeting 2021	0.5	1	3	0.2	1.1
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.1

FY21

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: xx/xx/xxxx

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

Contractual Costs: Description	Contract Sum
PWSSC Communications (network & phone) ($100/staff mo for network and $40/mo for phone + long distance)	1.5
PWSSC Postage and printing	0.5
Histology - slide mounting ($15/sample)	10.4
Histology - pathology reading ($10/sample)	6.9
Charter vessel (5 days at $2.5K/day)	12.5
Charter flights (4 hrs at $600/hr)	2.4
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$34.2

Commodities Costs: Description	Commodities Sum
Whirlpak bags	0.3
Histology cassettes	0.1
Cassette bottles	0.3
Formalin	0.8
Slides	0.2
Vials	0.1
Commodities Total	$1.8

FY21

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B CONTRACTUAL & COMMODITIES DETAIL

Date Prepared: xx/xx/xxxx

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

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
None			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency
Imaging software	1	ADFG

FY21

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B
EQUIPMENT DETAIL

Date Prepared: xx/xx/xxxx