



Exxon Valdez Oil Spill Trustee Council

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

Annual Project Reporting Form

Project Number: 24120111-E

Project Title: Herring Disease Program

Principal Investigator(s): Paul Hershberger and David Páez, U.S. Geological Survey, Western Fisheries Research Center, Marrowstone Marine Field Station

Reporting Period: February 1, 2024 – January 31, 2025

Submission Date: Feb 11, 2026

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.

Personnel changes.

1. Summary of Work Performed:

Field Sampling:

Prince William Sound Pre-spawn Adult Herring

Pacific herring (*Clupea pallasii*) were collected from three sites in Prince William Sound (PWS), Alaska (Table 1) during the spring pre-spawn period from March 29 – April 1, 2024, to test for viral hemorrhagic septicemia virus (VHSV), viral erythrocytic necrosis (VEN), and *Ichthyophonus* prevalence (Table 1). *Ichthyophonus* was detected in 33% (59/180) of heart cultures from all sites combined. An inverted pattern of decreasing *Ichthyophonus* infection prevalence with size started around 2019 and continued through 2024 (Fig. 1). VHSV was isolated from one fish collected in Canoe Pass. The isolation was at a very low titer and was detectable only after blind passage. Neutralizing antibodies to VHSV were detected in 4.4% (14/318) of PWS herring in 2024 (Fig. 2). Erythrocytic inclusions indicative of VEN were not



Exxon Valdez Oil Spill Trustee Council

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

Annual Project Reporting Form

detected in any PWS herring (n =180) from 2024, but bacterial rods were noted in the blood films from three fish.

Table 1. Infection prevalence results from Prince William Sound pre-spawn herring in 2024. VHSV = viral hemorrhagic septicemia virus and VEN = viral erythrocytic necrosis.

Location	Date	VHSV Prevalence	<i>Ichthyophonus</i> Prevalence (Heart Cultures)	VEN Prevalence
Red Head	March 29	0% (0/60)	27% (16/60)	2% (1/60) ^a
Canoe Pass	March 31	2% (1/60) ^b	37% (22/60)	0% (0/60)
Port Etches	April 1	0% (0/60)	35% (21/60)	0% (0/60)

^aIntracytoplasmic inclusions indicative of VEN were detected in one fish, and inclusion intensity was scored as 2/5, with 5 being the heaviest intensity.

^bThe fish was positive for VHSV after blind passage onto *epithelioma papulosum cyprini* cells; the minimum level of detection was 50 infectious particles /g of pooled tissue sample. Polyethylene glycol was used to increase cell culture sensitivity. The isolate was confirmed as VHSV by polymerase chain reaction.



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Long-Term Research and Monitoring, Mariculture, Education and Outreach
Annual Project Reporting Form

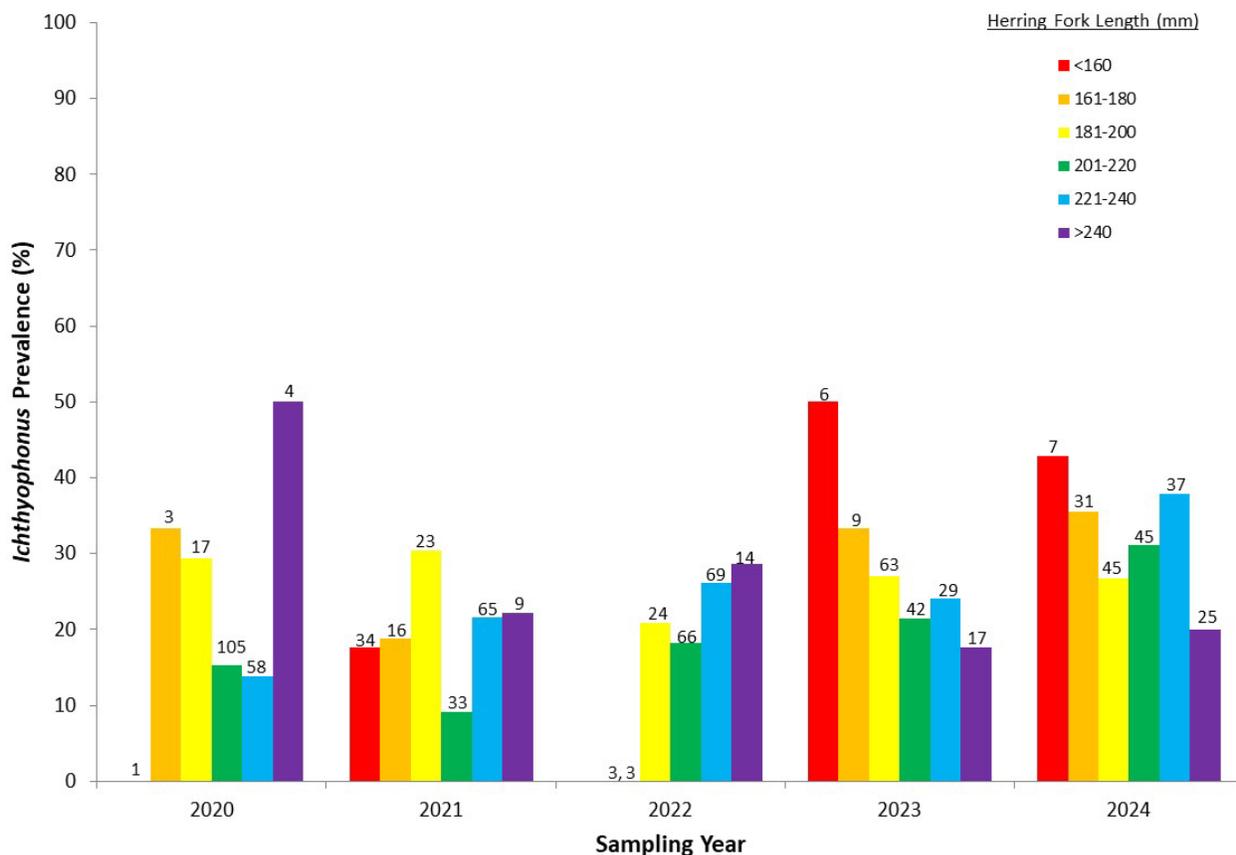


Figure 1. Temporal trend in *Ichthyophonus* infection prevalence in each size class of Prince William Sound herring. Numerals above each bar indicate sample size (n). Numerals immediately above the horizontal axis indicate the sample size for each size class with 0% infection prevalence.



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

Annual Project Reporting Form

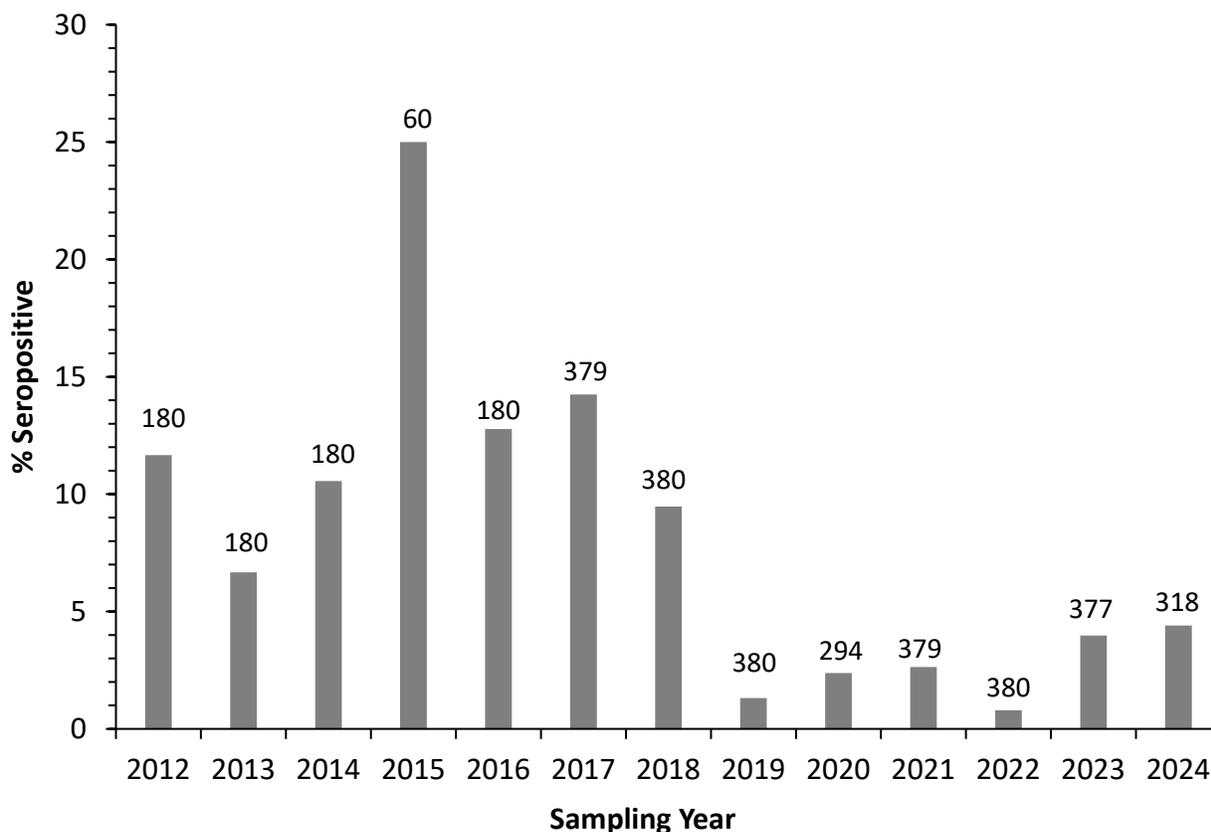


Figure 2. Annual prevalence of neutralizing antibodies against viral hemorrhagic septicemia virus in Prince William Sound herring. Numerals above the bars indicate the sample size (n).

Sitka Sound Pre-spawn Adult Herring

Adult Pacific herring were collected from three events in Sitka Sound, Alaska during the spring pre-spawn period from March 26-28, 2024, to test for VHSV, VEN, and *Ichthyophonus* prevalence (Table 2). *Ichthyophonus* was detected in 28% (48/171) of herring hearts. Neither VHSV nor VEN were detected in any samples (n = 171-172). Neutralizing antibodies to VHSV were detected in only 1% (2/164) of herring plasma samples (Fig. 4). As with PWS, VHSV neutralizing antibody levels have been relatively low in Sitka Sound for the past 6 years (2019-2024), inferring a paucity of VHSV exposures during this period and a current population of adult herring that remains susceptible to the resulting disease.



Exxon Valdez Oil Spill Trustee Council

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

Annual Project Reporting Form

Table 2. Infection prevalence results from Sitka Sound pre-spawn herring in 2024. VHSV = viral hemorrhagic septicemia virus and VEN = viral erythrocytic necrosis.

Location	Date	VHSV Prevalence	<i>Ichthyophonus</i> Prevalence (Heart Cultures)	VEN Prevalence
Deep Inlet	March 26	0% (n=60)	27% (16/59)	0% (0/59)
Deep Inlet	March 27	0% (n=52)	29% (15/52)	0% (0/52)
Deep Inlet	March 28	0% (n=60)	28% (17/60)	0% (0/60)

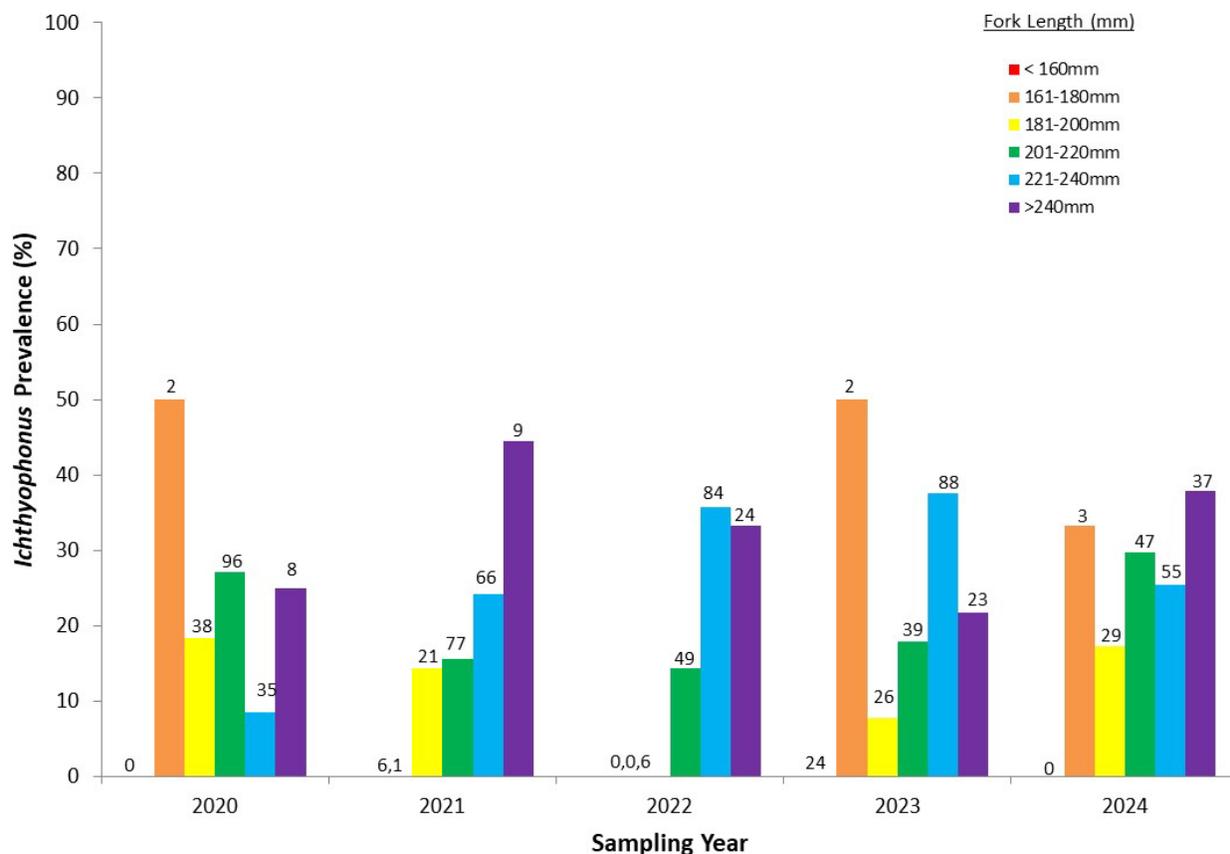


Figure 3. Temporal trend in *Ichthyophonus* infection prevalence in each size class of Sitka Sound herring. Numerals above each bar indicate (n). Numerals immediately above the horizontal axis indicate the sample size for each size class with 0% infection prevalence.



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

Annual Project Reporting Form

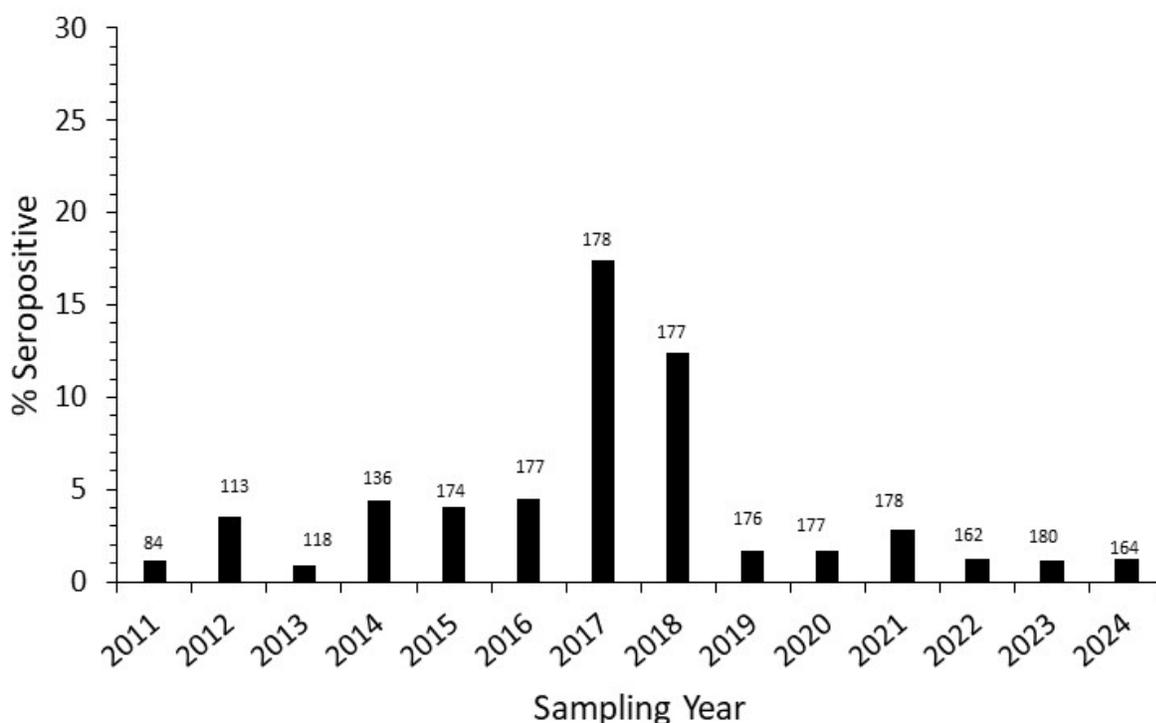


Figure 4. Annual prevalence of viral hemorrhagic septicemia virus neutralizing antibodies in Sitka Sound herring. Numerals above the bars indicate the sample size (n).

Puget Sound Pre-Spawn Adult Herring

Adult Pacific herring were collected from three sites in Puget Sound, Washington during the spring pre-spawn period from February 23 – March 12, 2024, to test for the prevalence of VEN, *Ichthyophonus*, and neutralizing antibodies to VHSV (Table 3). *Ichthyophonus* was detected in 5% (4/73) of herring hearts. VEN was not detected in any samples (n = 74). Neutralizing antibodies to VHSV were detected in 4% (3/73) of herring plasma samples.



Exxon Valdez Oil Spill Trustee Council

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

Annual Project Reporting Form

Table 3. Infection prevalence results from Puget Sound pre-spawn herring in 2024. VHSV = viral hemorrhagic septicemia virus and VEN = viral erythrocytic necrosis.

Location	Date	VHSV antibodies	<i>Ichthyophonus</i> Prevalence (Heart Cultures)	VEN Prevalence
Semiahmoo Bay	Feb 23	3% (n=30)	10% (3/30)	0% (0/30)
Squaxin Pass	March 1	3% (n=30)	0% (0/30)	0% (0/30)
Port Orchard	March 12	8% (n=13)	6% (1/16)	0% (0/14)

Selection for Ichthyophonus-infected herring by rhinoceros auklets

We hypothesized that avian predators may select for *Ichthyophonus*-infected herring because of decreased swimming performance and / or altered predator avoidance behavior by the infected host. As a pilot study to address this hypothesis, regurgitated age-0 herring were sampled from rhinoceros auklet (*Cerorhinca monocerata*) stomachs (collected from nesting birds in the Strait of Juan de Fuca, Washington) to assess the prevalence of *Ichthyophonus* infections in the consumed herring. Overall, 17 readable cultures from the hearts of regurgitated herring were obtained; *Ichthyophonus* prevalence was 6% (1/17). The sample size (n=17) was quite low, but the prevalence in these captured herring was approximately the prevalence we would have expected in newly metamorphosed wild herring. Because the *Ichthyophonus* prevalence was not atypically high, we did not further pursue this line of investigation.

Herring / Pink salmon interactions

Laboratory diagnostics were provided for the PWS pink salmon (*Oncorhynchus gorbuscha*) / herring interactions project (project 24220111-I, principal investigators [PIs] Rand and Gorman). Pacific herring and pink salmon were sampled from PWS during May – September 2024 and analyzed for the prevalence of VEN in blood films that were dried, methanol-fixed, and Diff-Quick-stained (Table 4). VEN was detected in several samples of juvenile (Age 0-2) Pacific herring, including 75% (3/4) from Hogg Bay on May 31, 100% (8/8) from Simpson Bay on June 2, 4% (2/56) from Sheep Bay on September 12, and 2% (1/50) from Whale Bay on September 14. Additionally, low VEN prevalences were detected in adult herring from Squire Point (3%, 1/30) on May 31 and Sheep Bay (14%, 1/7) on June 1. VEN was not detected in any pink salmon



Exxon Valdez Oil Spill Trustee Council

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

Annual Project Reporting Form

samples throughout the study period; however, pink salmon samples were rarely collected from locations containing herring with VEN. Collection of sympatric samples will be a point of emphasis in future study years. Results and conclusions are discussed in more detail in the annual report for project 24220111-I.

Table 4. Prevalence of viral erythrocytic necrosis (VEN) in pink salmon and Pacific herring from Prince William Sound cruises.

Location	Sampling Date	Fish species / Life Stage	VEN Prevalence (# Positive / n)
Mummy Bay	May 28	Herring (Adult)	0/27
Shelter Bay	May 29	Herring (Adult)	0/1
Fox Farm Bay	May 30	Herring (Age 1)	50/60
Hogg Bay	May 31	Herring (Age 1)	3/4
		Herring (Adult)	0/30
		Pink Salmon (Fry)	0/2
Squire Point	May 31	Herring (Adult)	1/30
		Pink Salmon (Fry)	0/1
Sheep Bay	June 1	Herring (Adult)	1/7
		Pink Salmon (Fry)	0/52
Simpson Bay	June 2	Herring (Age 1-2)	8/8
		Herring (Adult)	0/12
		Pink Salmon (Smolt)	0/7
Sleepy Bay	June 11	Pink salmon (Fry)	0/25
Prince of Wales	June 12	Pink Salmon (Fry)	0/20
Chenega	June 12	Pink Salmon (Fry)	0/19
Fox Farm	June 13	Pink Salmon (Fry)	0/19
Prince of Wales	June 27	Pink Salmon (Fry)	0/40
Chenega	June 27	Pink Salmon (Fry)	0/16
Sleepy Bay	June 28	Herring (Adult)	0/3
		Pink Salmon (Fry)	0/25
		Chum Salmon (Fry)	0/4
		Unidentified salmon (Smolt)	0/2
Pt. Brazil	June 28	Herring (Adult)	0/1
		Pink Salmon (Fry)	0/27
Pt. Brazil	July 8	Pink Salmon (Juvenile)	0/5
Sleepy Bay	July 8	Herring (Adult)	0/1
		Pink Salmon (Juvenile)	0/51
Prince of Wales	July 9	Pink Salmon (Juvenile)	0/13
Chenega Bay	July 9	Pink Salmon (Juvenile)	0/5
Sheep Bay	Sept 12	Herring (Age 0)	2/56
Zaikof Bay	Sept 13	Herring (Age 0)	0/50



Exxon Valdez Oil Spill Trustee Council

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

Annual Project Reporting Form

Location	Sampling Date	Fish species / Life Stage	VEN Prevalence (# Positive / n)
Whale Bay	Sept 14	Herring (Age 0)	1/50 ^a
Lower Herring Bay	Sept 15	Herring (Age 0)	0/30

^aExternal signs of ichthyophoniasis were observed on the positive Age-0 herring collected from Whale Bay on Sept 14.

Laboratory Studies:

Thiaminase activity and Ichthyophonus

A laboratory-based pilot study indicated that Pacific herring infected with *Ichthyophonus* had on average, 4.6 times higher thiaminase 1 activity in their tissue, compared to uninfected herring (n=11 / treatment; Fig. 5). The trend persisted in wild herring from Sitka Sound in spring 2024, where thiaminase activity was detected in 80% (n=5) of pre-spawn herring with *Ichthyophonus* infections but only 20% (n=5) of uninfected cohorts. Additionally, the levels of thiamine were lower among infected herring relative to the uninfected wild cohorts (Fig. 6). The elevated thiaminase I and low thiamine levels in these wild infected herring fall within levels that could contribute to thiamine deficiency complex in predatory fish. These preliminary findings were leveraged into a North Pacific Research Board (NPRB) proposal that was submitted to further evaluate these parasite / thiaminase relationships with more robust samples sizes and experimental designs.



Exxon Valdez Oil Spill Trustee Council

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

Annual Project Reporting Form

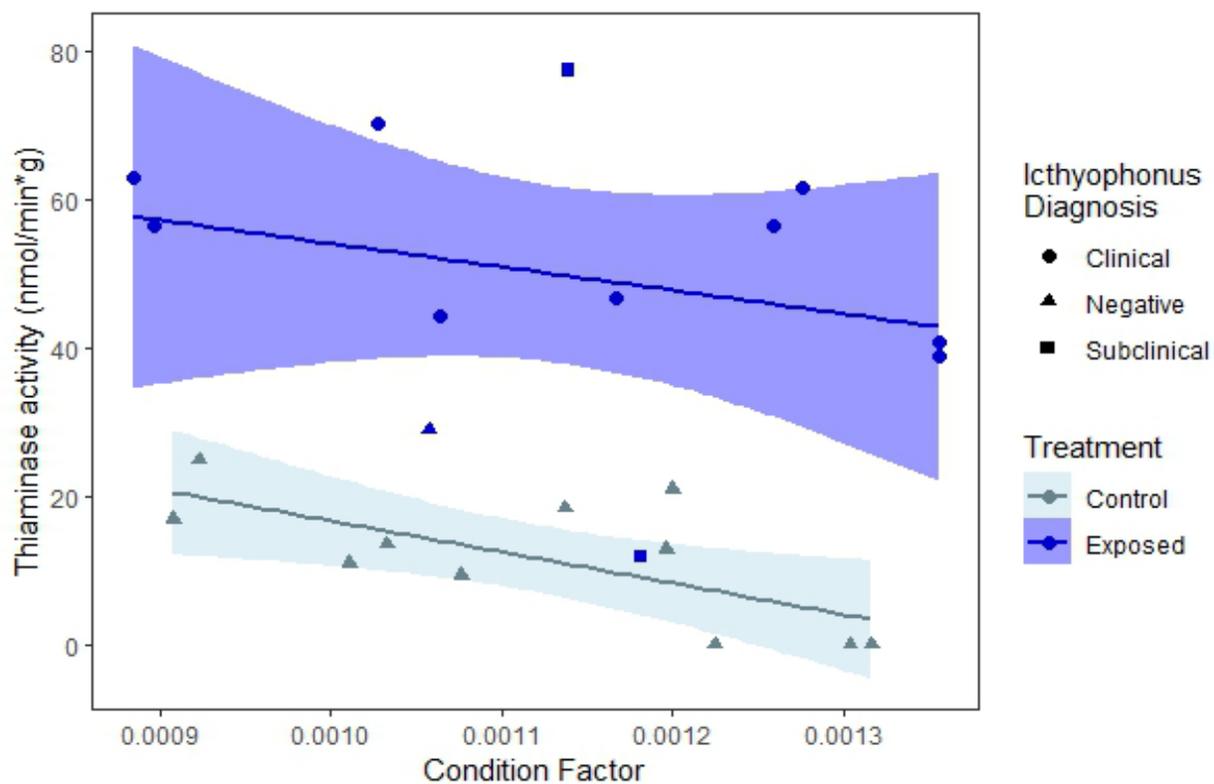


Figure 5 Thiaminase activity in laboratory-reared Pacific herring that were infected with *Ichthyophonus* relative to uninfected control herring.



Exxon Valdez Oil Spill Trustee Council

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

Annual Project Reporting Form

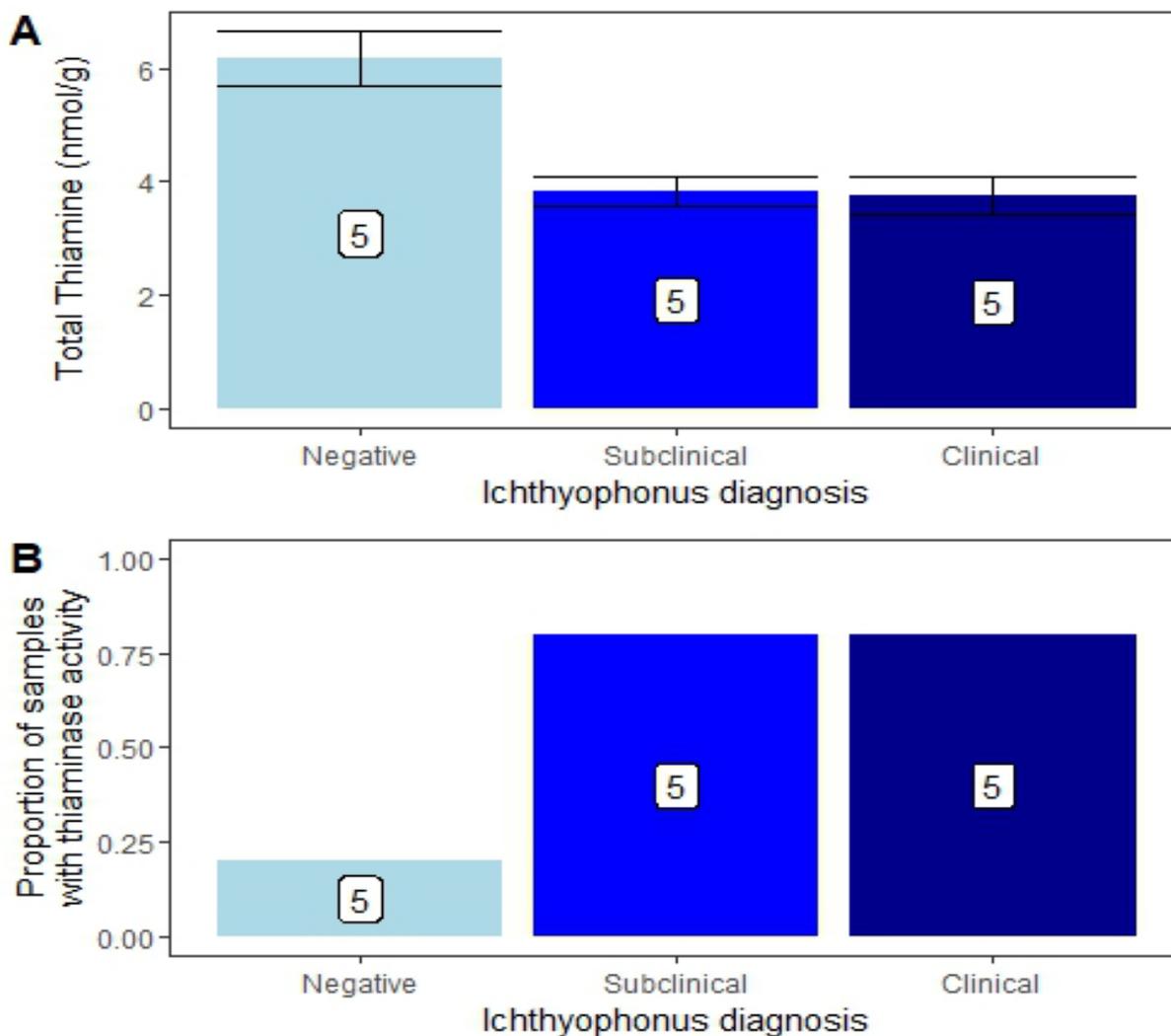


Figure 6. Total thiamine levels (A) and thiaminase activity (B) in wild Pacific herring from Sitka Sound relative to their *Ichthyophonus* infection status.

Effects of Ocean Acidification on herring susceptibility to VHS

Ocean acidification can affect the immune responses of fish, but effects on pathogen susceptibility remain relatively uninvestigated. Pacific herring were reared from hatch under three pCO₂ treatments [ambient (~650 μatm), intermediate (~1,500 μatm), and high (~3,000



Exxon Valdez Oil Spill Trustee Council

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

Annual Project Reporting Form

μatm] through metamorphosis (98 days) to evaluate effects of ocean acidification on bioenergetics and susceptibility to an endemic viral disease. Mortality from viral hemorrhagic septicemia (VHS) was comparable between herring reared under ambient and intermediate pCO_2 . In contrast, fish reared under high pCO_2 experienced significantly higher rates of VHS mortality (Fig. 7), and the condition factor of survivors was significantly lower compared to the other pCO_2 treatments. However, prevalence of infection among the survivors was not influenced by pCO_2 treatment. The pre-flexion development of larvae was not affected by elevated pCO_2 , as growth rate, energy use, and feeding activity were comparable across treatments. Similarly, long-term growth (14 weeks) was not affected by chronic exposure to elevated pCO_2 . Maximum swimming speed of juvenile fish was also not significantly affected by pCO_2 treatment. Herring reared under both elevated pCO_2 treatments showed an average reduction in swim speed; however, wide intra-treatment variability rendered the effect nonsignificant (Fig. 8). This study demonstrates that the VHS susceptibility and bioenergetics of larval and post-metamorphic Pacific herring are not affected by near-future ocean acidification predicted for coastal systems of the North Pacific. However, increased susceptibility to VHS in fish reared under 3,000 μatm pCO_2 indicates potential health and fitness consequences to extreme acidification.



Exxon Valdez Oil Spill Trustee Council

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

Annual Project Reporting Form

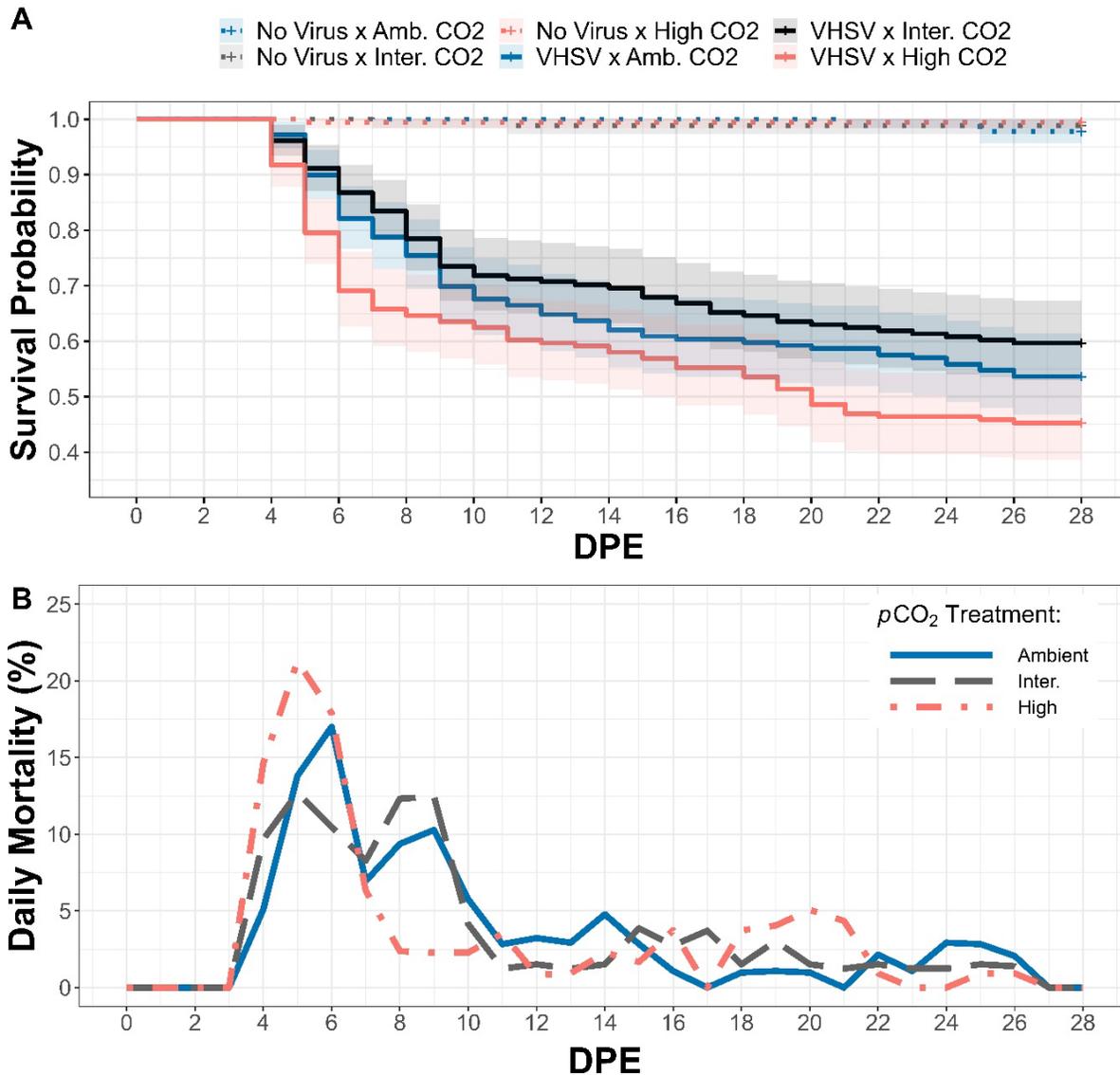


Figure 7. Effects of pCO₂ exposure history on susceptibility to viral hemorrhagic septicemia virus (VHSV) in juvenile Pacific herring (*Clupea pallasii*). (A) Kaplan Meier plot of the survival probability as a function of time (days-post exposure [DPE]) for juveniles exposed to VHSV (solid lines) or buffer only (no virus, dotted lines) crossed with three pCO₂ rearing treatments (intermediate treatment is abbreviated as inter.). Shaded areas around the lines indicate 95% confidence intervals of survival probabilities. (B) Percent average daily mortality (daily mortality divided by final cumulative mortality) of juveniles after water borne exposure to VHSV.



Exxon Valdez Oil Spill Trustee Council

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

Annual Project Reporting Form

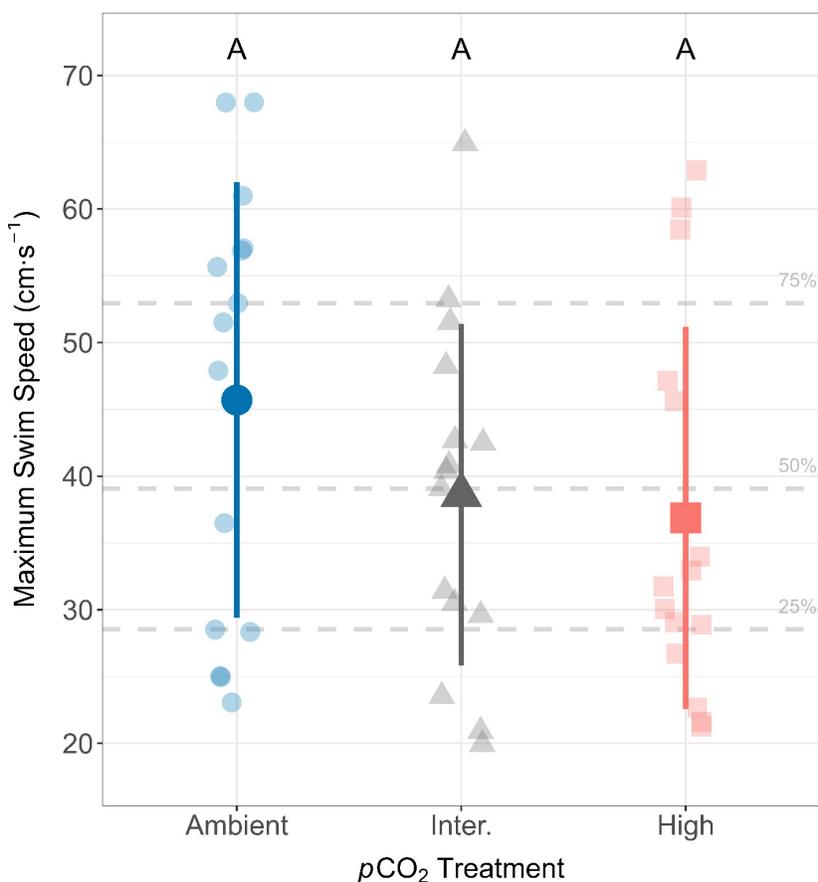


Figure 8. Maximum swim speed (U_{max} , $cm\ s^{-1}$) of juvenile Pacific herring (*Clupea pallasii*) reared under three pCO_2 treatments. Large colored symbols show treatment means and vertical lines denote \pm standard deviation. Small, faded symbols denote U_{max} for individual fish. Horizontal dashed lines identify quartiles calculated from U_{max} values pooled across pCO_2 treatments (intermediate treatment is abbreviated as inter.). Differing letters above bars indicate significant differences between treatment groups (Tukey's HSD).

Oviovory study

Several attempts were made to were made to test whether *Ichthyoponus* could be transmitted to Pacific herring through the consumption of parasite-associated walleye pollock (*Gadus*



Exxon Valdez Oil Spill Trustee Council

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

Annual Project Reporting Form

chalcogrammus) eggs. However, field impediments with the pollock collections prevented testing in 2024. Further efforts to test this hypothesis will continue in 2025.

Long Term Antibody study

A prior study indicated that neutralizing antibodies can be detected in 60% of VHS survivors 2.8 years after the initial laboratory exposure. However, when testing for antibodies in wild herring, we found that neutralizing antibodies were detectable in only approximately 27% of VHS survivors that were fully refractory to the disease (Hershberger 2023). Differences in the antibody kinetics between laboratory and wild fish may be reflective of continuous virus cycling between laboratory herring held in a tank, thereby artificially boosting antibody levels beyond what may be expected in the wild. Because we are trying to accurately assess the exposure history of groups of wild herring, we are seeking alternative techniques for more accurately deducing their exposure histories.

Since completing the aforementioned-laboratory-based studies, we have realized that VHSV remains in association with the gills of some VHSV survivors for extended periods. Therefore, this long-term follow-up experiment was designed to determine whether the detection of VHSV on herring gills can serve as a long-term proxy for deducing whether herring survived prior exposure and are now immune to the disease. In this study we exposed herring to VHSV in the laboratory, then traced their antibody levels at monthly intervals (similar to the previous study); additionally, these samples were paired with qPCR samples of gills to assess where gene copy number on the gills might serve as an alternative technique to deduce the VHSV exposure history in Pacific herring.

Briefly, neutralizing antibodies remain detectable in the plasma of VHSV survivors for at least 2.5 years after initial exposure (Fig. 9), supporting the results from the previous study. Neutralizing antibodies were not detected in any fish from the negative control group that were not exposed to VHSV (data not shown). The gill samples from these same fish are currently being processed; preliminary qPCR results should be available for the FY25 reporting period.



Exxon Valdez Oil Spill Trustee Council

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

Annual Project Reporting Form

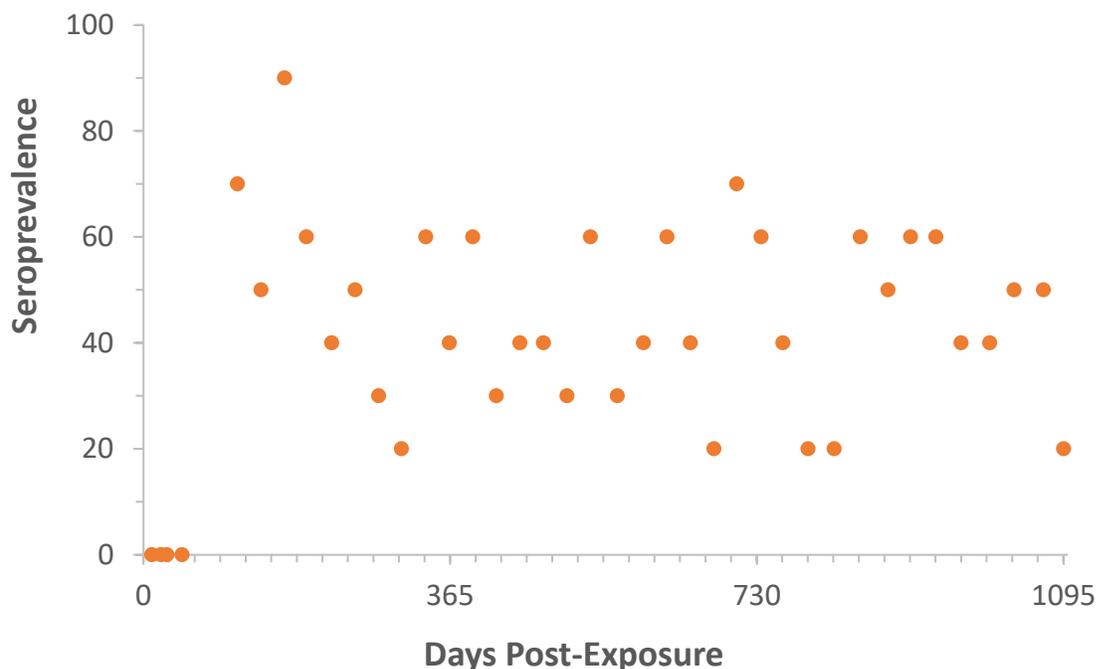


Figure 9. Detection of neutralizing antibodies in Pacific herring that survived a single VHSV exposure on October 22, 2021 (Day 0). Each data point reflects the seroprevalence based on a terminal subsample ($n = 10$). Antibody samples were paired with gill samples that will be processed by qPCR using VHSV primer sets (data not yet available).

Literature Cited:

Hershberger, P. K. 2023. Herring Disease Program II. Exxon Valdez Oil Spill Trustee Council Herring Research and Monitoring Project Final Report (Project 21120111-E). Exxon Valdez Oil Spill Trustee Council, Anchorage, AK.

2. Products:

Peer-reviewed publications:

Harsha, M. L., Y. Salas-Ortiz, A. D. Cypher, E. Osborn, E. T. Valle, J. L. Gregg, P. K. Hershberger, Y. Kurerov, S. King, A. I. Goranov, P. G. Hatcher, A. Konefal, T. E. Cox,



Exxon Valdez Oil Spill Trustee Council

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

Annual Project Reporting Form

J. B. Greer, J. P. Meador, M. A. Tarr, and P. L. Tomco. 2024. Toxicity of crude oil-derived polar unresolved complex mixtures to Pacific herring embryos: Insights beyond polycyclic aromatic hydrocarbons. *Science of the Total Environment* 957:177477.

Mihaljevic, J. R., and D. J. Paez. 2024. Systematic shifts in the variation among host individuals must be considered in climate-disease theory. *Proceedings of the Royal Society B* 291:20242515.

Murray, C. S., J. Gregg, A. MacKenzie, H. Jayasekera, T. Klinger, and P. K. Hershberger. 2024. The effects of elevated pCO₂ on bioenergetics and disease susceptibility in Pacific herring (*Clupea pallasii*). *Journal of Experimental Biology* 738:225-242.

Salzer, J. E., J. B. Greer, M. L. Groner, A. H. MacKenzie, J. L. Gregg, and P. K. Hershberger. 2024. Elevated temperature increases disease progression and host response of Pacific herring to viral erythrocytic necrosis. *Journal of Aquatic Animal Health* 34:45-56.

Reports:

No new contributions for this reporting period.

Popular articles:

No new contributions for this reporting period.

Conferences and workshops:

Lovy, J., W. M. Daniel, C. D. Raines, M. E. Neilson, M. Purcell, and P. K. Hershberger. 2024. AquaDePTH, building a national repository for the sharing and tracking of aquatic animal health data. Virtual presentation, 46th Annual Eastern Fish Health Workshop, Atlantic Beach, North Carolina, March.

Paez, D. J., S. Ferreiro-Luce, C. Grady, J. L. Gregg, V. Herron, and P. K. Hershberger. 2024. Platform. Sublethal Impacts of *Ichthyophonus* sp. infections on the swimming performance of Pacific herring. Oral presentation, Western Fish Disease Workshop, Boise, Idaho, July.

Paez, D. J., J. Gregg, and P. K. Hershberger. 2024. Platform. Prolonged impacts of VHSV infection on the swimming performance of Pacific herring. Virtual presentation, Ecology



Exxon Valdez Oil Spill Trustee Council

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

Annual Project Reporting Form

and Evolution of Infectious Diseases Conference, Stanford University, Palo Alto, California, June.

Páez, D. J., J. L. Gregg, A. H. MacKenzie, S. A. Hall, and P. K. Hershberger. 2024. Poster. Characteristics of a sea louse (*Caligus clemensi*) epizootic in wild Pacific herring (*Clupea pallasii*). Poster presentation, Alaska Marine Science Symposium, Anchorage, Alaska, January.

Páez, D. J., J. Lovy, J. Gregg, and P. K. Hershberger. 2024. Platform. Prolonged sublethal impacts of viral hemorrhagic septicemia virus infection on the swimming performance of Pacific herring. Virtual presentation, 2024 Ecology and Evolution of Infectious Diseases Conference, Palo Alto, California, June.

Páez, D. P., J. Lovy, J. L. Gregg, and P. K. Hershberger. 2024. Prolonged sublethal impacts of viral hemorrhagic septicemia on the swimming performance of Pacific herring. Poster presentation, Western Fish Disease Workshop, Boise, Idaho, July.

Waltzek, T., B. Torrevillas, A. Hassan, and P. K. Hershberger. 2024. Phylogenomic characterization of erythrocytic necrosis virus (ENV) from Pacific herring (*Clupea pallasii*). Virtual presentation, Western Fish Disease Workshop, Boise, Idaho, July.

Public presentations:

Hershberger, P. K. 2024. Update for the Puget Sound Partnership Forage Fish Workgroup: Roles of diseases and climate change affecting herring populations. Seattle, Washington, May.

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

We have been developing a nation-wide database for Aquatic Disease and Pathogens (AquaDepth). This U. S. Geological Survey (USGS)-hosted effort will serve as a repository for pathogen and disease surveillance data for freshwater and marine fish pathogens. The database infrastructure is currently being developed, and all the surveillance data from the past 15 years of the Herring Disease Program are at the top of the queue for inclusion. We anticipate that the database and the associated herring disease surveillance data will be public-facing in late 2026.



Exxon Valdez Oil Spill Trustee Council

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

Annual Project Reporting Form

Data sets and associated metadata:

Hershberger, P. 2024. Herring disease program. Gulf of Alaska Data Portal: <https://gulf-of-alaska.portal.aaos.org/#metadata/61b4ec5a-f15c-4347-b0ba-8a25ad763675/project>

Hershberger, P. 2024. Herring infection prevalence data, 2007-2023, EVOS herring program. Research Workspace. 10.24431/rw1k32b, version:10.24431_rw1k32b_20240405T202106Z.

Additional Products not listed above:

No new contributions for this reporting period.

3. Coordination and Collaboration:

Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government. All USGS field sampling and laboratory studies described in this report were approved by the USGS, Western Fisheries Research Center Institutional Animal Care and Use Committee (IACUC) Protocols #2008-51 and #2008-52. Additionally, this project was leveraged to obtain funding from the National Science Foundation (NSF) for a complementary herring disease study intended to evaluate the effects of climate change on herring diseases. The NSF project partners with Alaska Pacific University and Northern Arizona University.

The Alaska SeaLife Center or Prince William Sound Science Center

This project coordinates closely with the Prince William Sound Science Center (PWSSC), as the lead coordinator for the Herring Research and Monitoring (HRM) component. PWSSC provides administrative support, serves as a logistical liaison coordinating PWS herring cruises, and assists with metadata transfer for the Herring Disease Program.

EVOSTC Long-Term Research and Monitoring Projects

The Herring Disease Program is within the HRM component of the Gulf Watch Alaska-Long-Term Research and Monitoring (GWA-LTRM) program. We work with other HRM component projects as the component as a whole works to understand the lack of recovery of PWS herring, particularly the following projects:



Exxon Valdez Oil Spill Trustee Council

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

Annual Project Reporting Form

- We work closely Alaska Department of Fish and Game (ADF&G; project 24170111-F: Herring surveys and age, sex, and size collection and processing; PI Morella to collect herring tissue and plasma samples, using a shared platform for the spring herring cruises. Additionally, ADF&G provided age data for the fish health samples.
- Pathogen survey data are shared with Dr. Trevor Branch for incorporation into the age structured analysis model (project 24120111-C: Modeling and stock assessment of PWS herring). Additionally, revised antibody data for PWS were shared with Dr. Branch, for incorporation into a VHSV hindcasting model.
- This project will provide pathogen surveillance information for Drs. Rand and Gorman (project 24220111-I: Ecological interactions between Pacific herring and Pacific salmon in PWS). VEN surveillance results for pink salmon / herring interactions are included in their report.

EVOSTC Mariculture Projects

The Herring Disease Program has not coordinated with EVOSTC mariculture projects. However, if these projects would benefit from herring disease data, publications, and reports, we would be happy to work with them.

EVOSTC Education and Outreach Projects

Project team members participated in the Ocean Sciences Festival coordinated by the Community Organizes Restoration and Learning (CORaL) Network at Cordova High School in October 2024.

Individual EVOSTC Projects

The Herring Disease Program works with the Data Management program to ensure our data are properly reviewed, have current metadata, and are posted to the Gulf of Alaska data portal within required timeframes. We will work with other individually funded EVOSTC projects if collaborative efforts make sense based on data collected.

Trustee or Management Agencies

USGS is a Trustee Agency, and our herring disease work complements other fisheries disease research conducted at the Marrowstone Lab. In addition, we partner with ADF&G on a variety of disease issues, specifically the following:



Exxon Valdez Oil Spill Trustee Council

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

Annual Project Reporting Form

- We collect herring infection and disease data onboard the shared ADF&G seining platform in coordination with Cordova-based biologists.
- We collect herring infection and disease data from pre-spawn aggregations in Sitka Sound with Sitka-based biologists.
- We continue to partner with ADF&G Juneau Fish Pathology Laboratory who has provided consistency for processing all fish virology samples from PWS and Sitka Sound since the onset of herring health assessments in the early 1990s.

Native and Local Communities

The Ocean Sciences Festival targeted students in Cordova and the Eyak Tribe. The Cordova community and Eyak Tribe were directly affected by the decline in herring and fishery closure.

4. Response to EVOSTC Review, Recommendations and Comments:

September 2024 EVOSTC Science Panel Comment:

This PI continues to provide outstanding productivity. The work in this project is immediately relevant to the status of Pacific herring in Prince William Sound. It also provides fundamental information regarding the annual herring stock assessment process. This very comprehensive project is on track and ahead of schedule. The project focus is on disease interactions but also includes impacts of oil-related compounds (PAHs) on herring heart development. The PI provides a nice demonstration in a flow-through system of how PAHs below chemical detection methodology induces abnormal heart development in developing herring. Antibody levels in sera are extremely useful for assessing disease exposure and resistance in the population. The Science Panel is excited to see this endpoint included in fisheries assessment models in the future.

We had a few questions and comments.

Both of the annual reports have a number of small editorial issues that detract from clarity. For example, Figures 1 and 4 in the FY22 annual report and Figures 1 and 3 in the FY23 annual report are difficult to follow. In both years the figure caption indicates a ‘trend’ but the trend was not clear from the graph. It is difficult to see any trend when the size groups are shown as separate colors. Perhaps there are size-specific trends, but none that we could readily see from



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Annual Project Reporting Form

the graphs, as presented. Perhaps the figure captions could be expanded or, preferably, the figure could be presented differently.

PI Response:

Agreed. We were attempting to consolidate all sampling years into a single figure, but the figure has simply become too complex. Therefore, we can scale back the figure to only display the most recent 5 years.

September 2024 EVOSTC Science Panel Comment:

We appreciate the informative text about different strains of *Ichthyophonus* (Figure 7 in FY22 annual report but wonder if it would ever be feasible to detect differences at finer (within species) geographic levels? Similarly, the text (Part c – a novel approach) on using disease data into assessment models is certainly novel and remarkable. We encourage persistence in this approach.

PI Response:

Thank you for the comments. We had the same idea, and we are actively trying to get down to a finer geographic scale. We are in the process of accumulating additional isolates from different host species collected within PWS and the Gulf of Alaska to do exactly what the Reviewer is requesting. We hope to be able to add this to the final report as a no-cost addition to the project.

September 2024 EVOSTC Science Panel Comment:

On page 18, we wondered about ‘pathogen surveillance information’ that would be shared with project 22220111 (interaction between herring and salmon). We would like to see clarification on this in future reports.

PI Response:

We were referring to the VEN diagnostics that we are providing for Project 22220111. The VEN results for 2024 are included in this report (Table 4).

September 2024 EVOSTC Science Panel Comment:

In the FY23 annual report we appreciate the informative but preliminary text on *Ichthyophonus*, including how it has affected shad and other species. We noted that there are a number of small



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Annual Project Reporting Form

typographical errors in this text (see the paragraph under ‘swim performance’ in shad). Further, the speculation about a correlation between age-specific infection that might account for differences in herring year class strength between PWS and Sitka is interesting. Will there be opportunities to expand on this in the next few years?

PI Response:

Yes. The previous assessment encompassed the years 2007-2019. We anticipate performing an additional assessment on the age-specific infection rates after we have a few more years of survey data to contribute to the analysis.

September 2024 EVOSTC Science Panel Comment:

On page 17 there is some interesting text about VHS and temperature and refers to “Fig. 1” but this does not appear to correspond to Figure 1 (page 3 of the FY23 annual report). The topic is interesting, and we would be grateful for a follow-up on this topic in the next annual report.

PI Response:

The full analysis of the Susceptible, Exposed, Infected, Recovered model for VHSV in herring is being performed through the sub-award at Bigelow Labs. The draft manuscript has gone through several reviews with the co-authors, but it is not yet ready for dissemination. This should be ready for full reporting in the FY’25 annual report.

September 2024 EVOSTC Science Panel Comment:

The preceding questions and comments on minor typographical errors (i.e., the format errors in part A, Figure 9) notwithstanding, the work and progress presented in these two years of reports is excellent.

The Science Panel has no concerns about this project.

PI Response:

We would like to thank the Science Panel, PAC, and all other reviewers for their thoughtful and insightful comments, and we greatly appreciate the continued support for this project.



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Annual Project Reporting Form

5. Budget:

Below is the cumulative spending summary for the herring disease program project. The budget includes spending by USGS and the project collaborator at Bigelow Lab.

**EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM 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	\$221,276	\$310,206	\$227,886	\$235,462	\$301,248	\$1,296,078	\$541,075
Travel	\$21,826	\$21,826	\$21,826	\$21,826	\$21,826	\$109,130	\$26,709
Contractual	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Commodities	\$39,300	\$39,000	\$39,000	\$39,000	\$39,000	\$195,300	\$93,872
Equipment	\$15,000	\$0	\$0	\$0	\$0	\$15,000	\$15,000
Indirect Costs (varies by proposer)	\$18,424	\$18,424	\$0	\$0	\$0	\$36,849	\$22,207
SUBTOTAL	\$315,826	\$389,456	\$288,712	\$296,288	\$362,074	\$1,652,357	\$698,863
General Administration (9% of subtotal)	\$28,424	\$35,051	\$25,984	\$26,666	\$32,587	\$148,712	N/A
PROGRAM TOTAL	\$344,251	\$424,508	\$314,696	\$322,953	\$394,661	\$1,801,069	
Other Resources (In-Kind Funds)	\$124,245	\$127,724	\$131,396	\$135,129	\$138,910	\$657,404	

COMMENTS:
 This is the combined budget for PIs Hershberger and Paez at USGS and collaborator Groner at Bigelow Lab. The contract for collaborator Groner will run through PWSSC's NOAA grant. Please see attached budgets for details. Both portions of the project are behind in spending because of the delay in issuing funds beginning in FY22.

FY22-26	Project Number: 24120111-E Project Title: Herring Disease PI(s): Hershberger & Paez (USGS) Collaborator: Groner (Bigelow)	SUMMARY TABLE
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