Exxon Valdez Oil Spill
Long-Term Herring Research and Monitoring Program Final Report

Juvenile Herring Abundance Index

Exxon Valdez Oil Spill Trustee Council Project 16120111-F
Final Report

Peter S. Rand
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Study History: Juvenile herring cruises supported by the *Exxon Valdez* Oil Spill Trustee Council began in FY07 and continued through FY10 with project 10100132-B. A series of cruises involving hydroacoustics began in November 2007. Additional hydroacoustic surveys, with additional locations added, were conducted in March 2010, November 2010 and March 2011. These surveys, however, lacked efforts at direct capture to confirm species identification, and thus it is difficult to interpret results for patterns in Pacific herring distribution and abundance. Additional juvenile herring surveys were conducted in Simpson and Windy Bays during 2012-2014 (project 15120111- G) to evaluate variability in surveys conducted at 2-week intervals in the fall and spring periods.

Abstract: Pacific herring (*Clupea pallasii*) have not recovered in abundance since their decline in the early 1990s in Prince William Sound, Alaska. Annual monitoring of the adult population has been on-going for decades, but less attention has been focused on the juvenile stages. We tracked seasonal and spatial patterns in densities of juvenile Pacific herring (ages 0 and 1, individuals km^{-2}, occupying the top 30 m of the water column) using hydroacoustics in November in seven bays and fjords throughout Prince William Sound during 2012-2015, and five bays in 2016. We relied on trawl catches to apportion total backscatter to juvenile herring. Across the Prince William Sound bays surveyed we found consistent trends of higher acoustic backscatter in the inner bays compared to the outer bays and greater abundance of fishes to the right of the main bay axis. The ranking of biomass across bays was not consistent from year to year, but we observed densities of juvenile herring to be significantly lower in 2013, which suggests a poor year class. This approach may provide an early, independent measure of year class strength for use in predicting subsequent recruitment to the adult population. A number of challenges exist for monitoring juvenile herring, particularly surveying in shallower habitat and increasing our understanding of movements of juvenile herring across different habitats.

Key words: *Clupea pallasii*, hydroacoustic survey, juvenile Pacific herring, mid-water trawl capture, Prince William Sound bays and fjords

Project Data:
*Description of dat*a – Acoustic data is in the form of *.DT4 files that contain the GPS cruise track and measures of acoustic backscatter collected on each research cruise. Data were analyzed using Echoview 7.1, and echointegration results are exported in the form of *.CSV files. Trawl data used to groundtruth estimates are archived under Exxon Valdez Oil Spill Trustee Council project (16120111-A).

Data archive and custodians –
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https://portal.aoos.org/gulf-of-alaska.php#metadata/81ce911c-4162-4f26-bad6-4e2764a24b2d/project
There are no limitations on the use of the data, however, it is requested that the authors be cited for any subsequent publications that reference this dataset. It is strongly recommended that careful attention be paid to the contents of the metadata file associated with these data to evaluate data set limitations or intended use.

Citation:

Rand, P.S. 2018. Juvenile herring abundance index. *Exxon Valdez* Oil Spill Long-Term Herring Research and Monitoring Program Final Report (*Exxon Valdez* Oil Spill Trustee Council Project 16120111-F), *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

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EXECUTIVE SUMMARY

Pacific herring (*Clupea pallasii*) have not recovered in abundance since their decline in the early 1990s in Prince William Sound (PWS), Alaska. Annual monitoring of the adult population has been on-going for decades, but less attention has been focused on the juvenile stages. We tracked seasonal and spatial patterns in densities of juvenile Pacific herring (ages 0 and 1, individuals km^{-2}, occupying the top 30 m of the water column) using hydroacoustics in November in seven bays and fjords throughout PWS during 2012-2015, and five bays in 2016. We relied on trawl catches to apportion total backscatter to juvenile herring.

We employed a mobile, acoustic survey design in separate bays. Transects were conducted after sunset, and the deck lights were extinguished to avoid responses of herring to light. During each night survey, 1 to 4 separate, midwater trawls were conducted to determine species and size distribution of acoustic targets. During 2012, we relied on gill net and cast net samples to characterize size of surveyed herring. We partitioned the acoustic backscatter into three categories: Pacific herring, walleye pollock (*Gadus chalcogrammus*), and other fishes (mostly consisting of capelin (*Mallotus villosus*). Based on the catch data, we estimated the proportion of the total herring captured that were juveniles and multiplied this by acoustically-derived fish density to arrive at an estimate of juvenile herring density.

The survey area (in km^2) was estimated as the convex hull containing the set of coordinates of the ship's track during each acoustic survey. We examined the main effects of bay and year on densities by applying ANOVA. We evaluated spatial patterns in the acoustic data by applying a generalized linear regression model. We evaluated whether our conclusions were robust to changes in the depth strata that delineates the habitat for juvenile herring in our study by repeating our statistically analyses after adjusting the depth threshold applied to our acoustic data set (± 10 m from nominal 30 m threshold).

The catches in the trawls indicated that the pelagic fish community was dominated by Pacific herring, making up a majority of trawl catches (numerical median proportion = 0.86). Walleye pollock (*Theragra chalcogramma*) was found to be the second most common species encountered, with a median catch proportion of 0.05. Median catch proportion of other fish, consisting almost entirely of capelin, was estimated to be 0.02.

We report results from four cruises with surveys of seven bays for a total of 28 separate acoustic surveys. The area acoustically surveyed ranged from 9.9-36.1 km^2. The mean density of juvenile herring over the four years was highest in Whale Bay, and lowest in Lower Herring Bay. Whale Bay also showed the highest inter-annual variance (113% coefficient of variation across the 4 years). The highest density of juvenile herring during a given night survey was observed in Whale Bay in 2014 (909,465 herring km^{-2}). The lowest densities of juvenile herring were observed in 2013 in Fidalgo (nil, based on a lack of herring in trawl catches), Eaglek (95 herring km^{-2}) and Lower Herring (585 herring km^{-2}). Results indicate that juvenile herring abundance (fish km^{-2}) was significantly lower in 2013 compared to all the other years of the survey ($p=0.01$). Herring densities observed during 2012 were significantly greater than 2013 ($p=0.01$) and 2013 was found to be lower than 2014 ($p = 0.03$) and 2015 ($p = 0.03$).

Across the PWS bays surveyed we found consistent trends of higher acoustic backscatter in the inner bays compared to the outer bays. Our results were robust to the assumptions of the depth distribution of juvenile herring in the study area.

This approach may provide an early, independent measure of year class strength for use in predicting subsequent recruitment to the adult population. A number of challenges exist for monitoring juvenile herring, particularly surveying in shallower habitat and increasing our understanding of movements of juvenile herring across different habitats.

INTRODUCTION

Management of the Pacific herring (*Clupea pallasii*) stock in Prince William Sound (PWS), Alaska, is based primarily on an age-structured-assessment (ASA) model. The current model, developed in 2005 by the Alaska Department of Fish and Game, incorporates both hydroacoustic estimates of the adult herring biomass and an index of the male spawning, called the "mile-days of spawn". Unfortunately, the forecast is based on measurements from the previous year and does not have a direct measure of future age-3 recruitment. Current knowledge suggests that most mortality occurs during the first winter of life, so the relative recruitment may be fixed by the end of the first year. Consequently, estimates of relative abundance of age-1 and age-2 fish should provide an index of future recruitment. An index of age-0 fish would also provide a forecast of recruitment if additional information were available on the magnitude of the first year mortality. We proposed to conduct annual fall surveys (FY2013-2016) of 8 bays; four of which will be bays that were surveyed during the the Sound Ecosystem Assessment project (Cooney et al. 2001). This will maintain a continual database from these locations. Additional bays were added based on survey results of the *Exxon Valdez* Oil Spill Trustee Council (EVOSTC) project 10100132-B. We proposed surveys to be conducted using 120 kHz split-beam hydroacoustic unit in a stratified systematic survey design (Adams et al. 2006). For this study, direct capture was directed to size and species composition. Trawl captures were intended to help apportion the acoustic data.

OBJECTIVES

This project was intended to provide information to improve input to the age-structure-analysis (ASA) model, or test assumptions within the ASA model.

Project Objectives:

1. Conduct annual surveys of juvenile herring to create an index of future recruitment

2. Validate species and size composition of fish ensonified during acoustic transects (See project report 16120111-A, Bishop and Lewandoski 2018).

METHODS

Surveys

We conducted coupled acoustic and trawls during November from 2012-2015 in each of seven separate bays and fjords in PWS (Fig. 1). In November 2016 we completed acoustic and trawl captures in 5 bays (Gravina, Eaglek, Lower Herring, Whale and Zaikof Bays). Acoustic and trawl data collected during 2016 has not yet been analyzed and results are not reported here.

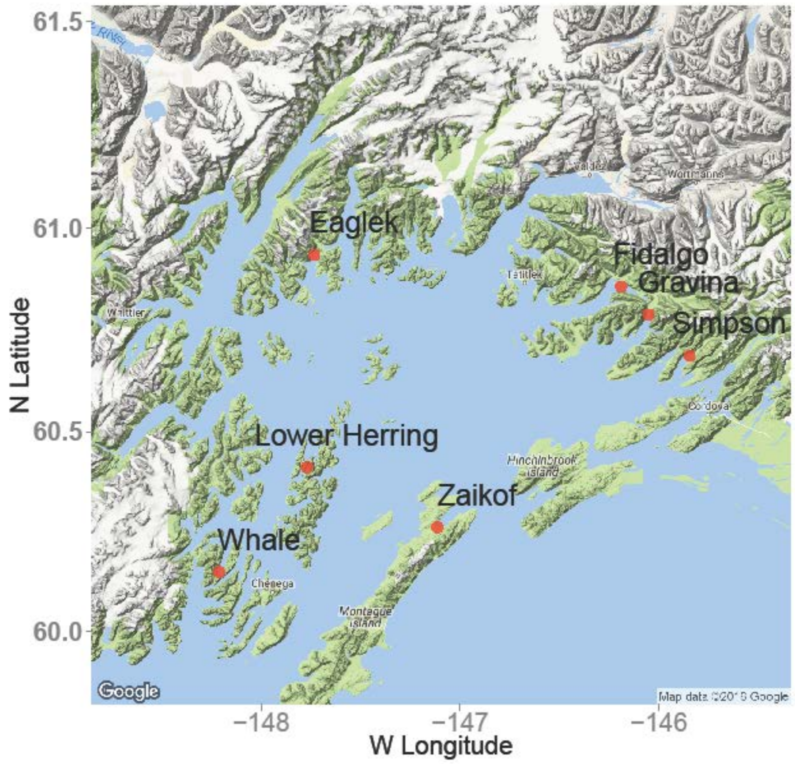

Figure 1. Location of bays and small fjords in Prince William Sound surveyed for this project.

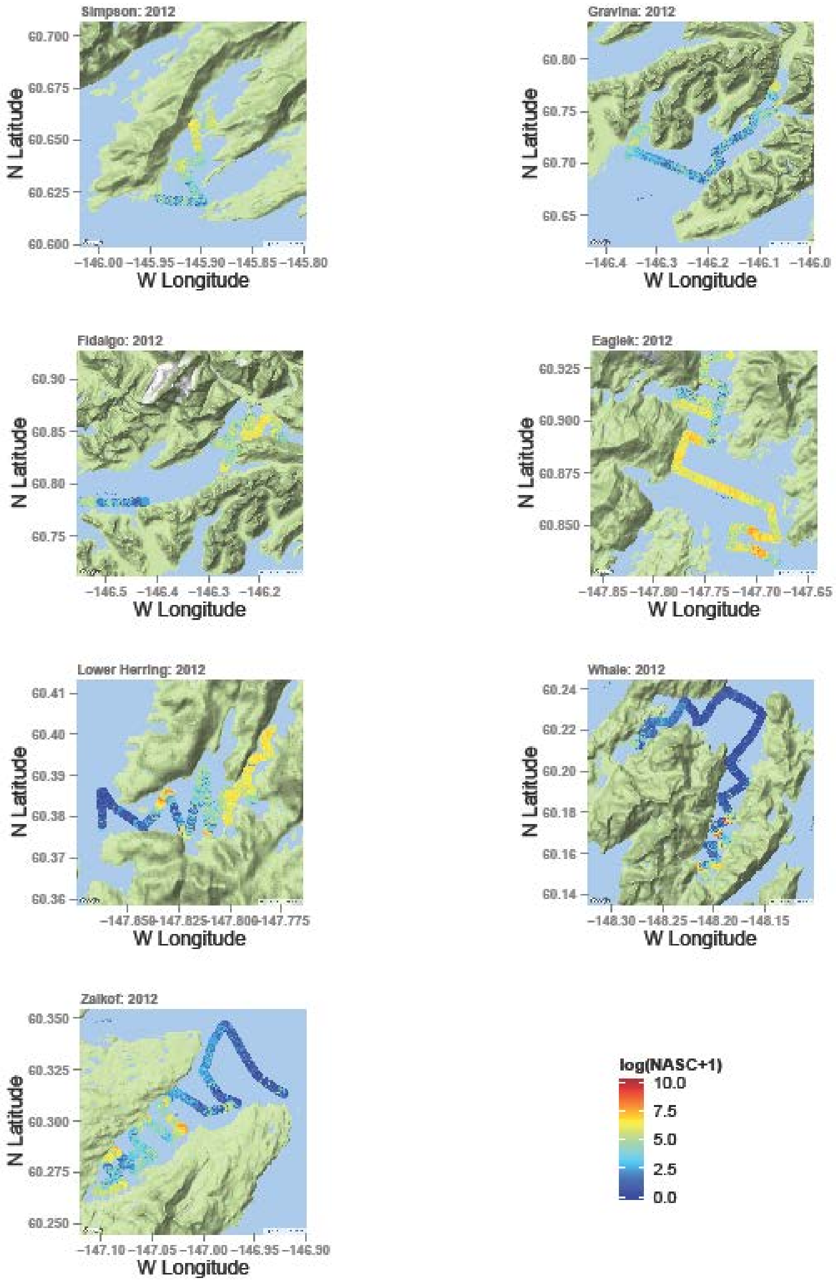

Figure 2. Survey cruise tracks in each bay surveyed in this project (example is from 2012, the first year of the project). False color spectrum reflects intensity of acoustic backscatter measured along the transect (NASC, in $m^2 nm^{-2}$).

These surveys sampled seven separate bay and fjord systems in Prince William Sound around the period of the new moon. Windy Bay on Hawkins Island in the southeastern part of PWS was included in this survey, but due to a lack of consistent catches of Pacific herring in this system, we did not include this bay in our analysis. A combination of transect designs were employed based on the physical characteristics of the water body (Fig. 2). In most cases we used the traditional zig-zag, mobile transect design (Thorne 1983; Stokesbury et al. 2002). An effort was made to survey across the inner and outer main bay axis and across the bay axis when feasible. The bays were visited and sampled on one night each year over a cruise period of approximately 10 days.

Coupled Acoustic and Trawl Data Collection

To collect acoustic data, a BioSonics 124 kHz digital split-beam transducer (7.6^{o} beam) was mounted down-looking on a 1.2 m long aluminum towfin and deployed off an 18 m vessel (F/V *Montague*). The echosounder was configured to transmit 3 pings s^{-1}, the source level was 221.2 dB (re 1 µPa at 1 m) with a pulse duration of 0.4 ms. Transects were conducted after sunset, and the deck lights were extinguished to avoid responses of herring to light. Tow speeds were maintained at approximately 2-3 knots and the transducer was positioned approximately 1-2 m below the surface. The transducer was calibrated by the standard sphere method (Foote et al., 1987), and calibration results were determined to vary <1.5% during the last three years of this study. Position of the vessel along the transect was recorded with a Garmin 17x NMEA 0183 high-sensitivity GPS (accuracy rating under typical conditions < 10 m) connected via a power/data cable to the BioSonics DT-X top box so GPS coordinates were integrated as a cruise track into the *.DT4 data files.

During each night survey, 1 to 4 separate trawls were conducted to determine species and size distribution of acoustic targets Juvenile herring were captured using a midwater trawl (14 m × 11 m × 22 m; Innovative Net Systems, Inc., Milton, LA) with a 38 mm mesh size reducing down to 12 mm mesh at the codend. Trawl tows were carried out onboard the same vessel conducting the hydroacoustic surveys, and the same trawl was used for all cruises. Tows were generally limited to 20 min duration. Tows were conducted immediately following completion of hydroacoustic surveys in areas where high acoustic backscatter had been detected. No trawl data were collected during the 2012 survey. For that year we relied on mean sizes of Pacific herring estimated from catches using a combination of cast nets (1/4 inch mesh) and gill nets (small mesh: 60' x 16', with panels of 1/4, 5/16, 3/8 inch mesh; and larger mesh: 160' x 16' with panels of 1/4, 3/8, 1/2, 3/4 inch mesh) during the night while the vessel was at anchor near the head of the bays.

We pooled trawl data over all trawls conducted each night of the survey. Fishes were identified to species and were measured (standard, fork and total lengths to the nearest millimeter) onboard the research vessel. We measured lengths from a subsample of catches up to a total of 200 individuals per night. We considered juvenile herring (ages 0 and 1) to be <= 150 mm TL. We averaged lengths from this pooled sample for use in estimating target strength separately for each night’s acoustic survey (see below).

Acoustic data were manually inspected and post-processed in Echoview 7.1 (Sonar Data Pty., Ltd.). A -60.0 dB threshold was applied to the mean volume backscattering strength echograms (S_V, MacLennan et al. 2002) prior to echo integration. A bottom detection algorithm was manually edited to remove echoes from the substrate and associated sources of acoustic backscatter. Additional manual inspections removed any remaining undesired data (i.e., reverberation, bubble noise, etc.) and the echograms were binned into 10 m horizontal by 10 m depth analysis cells. Backscatter below 30 m was excluded from further analysis (although see Sensitivity Analysis section below), as the trawl was not capable of capturing fish deeper than 30 m in the water column. Further, these deeper depths are not preferred habitat for juvenile Pacific herring (Stokesbury et al. 2000). Acoustic data were echo integrated in Echoview, and were output in the form of the area backscatter coefficient (sa, m^2 m^{-2}) for echo-integration or the nautical area scattering coefficient (NASC, m^2 nm^{-2}, as in MacLennan et al. 2002) for purposes of plotting and evaluating spatial patterns.

We partitioned the acoustic backscatter into three categories: Pacific herring, walleye pollock (*Gadus chalcogrammus*), and other fishes. To estimate echo amplitudes for each category, we applied the general equation:

$$TS = 20 \log_{10} L - 2.3 \log10(1 + Z/10) - b_{20}$$

Where L is mean fork length (cm), Z is mean water depth (m) and b20 is the species-specific intercept value. Lengths for each category were derived from fish collected in either trawls or, during 2012, in cast or gill nets. Depths, Z, for each analysis bin (10, 20 and 30 m) were applied in the equation. We applied values from the literature for b_{20}: Pacific herring (-65.4, Thomas et al. 2002), walleye pollock (-66, Traynor 1996) and a generalized physoclist fish for the other fish category (-67.4, Foote et al.1987).

The mean target strength (dB) for each fish category was calculated as described above and converted to linear echo amplitude (σ_{bs}, m^2 where σ_{bs} =10(TS/10), as in MacLennan et al. 2002). Linear echo amplitudes were summed for each trawl (i.e. sum of σbs for all fish, total echo amplitude) and for each target category (herring, pollock or other fishes) within the trawls in a given night. The trawl-derived acoustic species proportion for each night of trawls was then calculated by dividing the species echo amplitude by the total echo amplitude for the trawl (Parker-Stetter et al. 2013).

We report on numbers of herring derived from the herring proportion of s_a for each sampling distance unit (EDU, MacLennan et al. 2002):

$$\text{Fish density (no. of herring} \cdot \text{km}^{-2}) = s_a / 10^{(TS/10)} \cdot 10^6$$

Based on the catch data, we estimated the proportion of the total herring captured that were juveniles and multiplied this by fish density to arrive at a juvenile herring density. The survey area (in km^2) was estimated as the convex hull containing the set of coordinates of the ship's track during each acoustic survey. We examined the main effects of bay and year on densities by applying ANOVA. We tested for differences across treatments (bay and year, at $p < 0.05$) using the Tukey post hoc test.

We evaluated spatial patterns in the acoustic data by applying a generalized linear regression model. The response variable was NASC (log transformed, and summed over depth interval 0 – 30 m). The latitude and longitude coordinates at each 10 m EDU across the entire survey transect were included as explanatory variables. To align the main bay axis to compass North, we rotated the transect latitude and longitude coordinates around a point at the head of each bay. We considered positive regressions along latitude as support for the hypothesis of higher densities of fish in the inner vs. the outer bay. This allowed us to interpret significant regression coefficients describing patterns over northing directions as changes across the main bay axis. We considered regression coefficients with p values < 0.05 to be significant, and expressed the resulting slope parameters as changes in densities across distance in kilometers assuming 1 degree latitude = 111 km.

Evaluating sensitivity to the depth threshold

We evaluated whether our conclusions were robust to changes in the depth strata that delineates the habitat for juvenile herring in our study. While Stokesbury et al. (2000) defines surface waters of 0-30 m as preferred habitat for juvenile herring, we acknowledge this could be a source of uncertainty in our analysis. We adjusted this nominal value of 30 m up and down by 10 m (i.e. applied thresholds of 20 and 40 m) and quantified divergence (proportional change) from the baseline estimate of juvenile herring density. By repeating some of the key statistical analyses, we determined if some our key results are robust over this threshold range.

All statistical analyses were carried out using R version 3.2.0 (2015-04-16).

RESULTS

Coupled acoustic and trawl surveys were completed in all seven bays during 2012-2015 (Table 1). The catches in the trawls indicated that the pelagic fish community was dominated by Pacific herring, making up a majority of trawl catches (numerical median proportion = 0.86, Fig. 3). Walleye pollock was found to be the second most common species encountered, with a median catch proportion of 0.05. Median catch proportion of other fish, consisting almost entirely of capelin, was estimated to be 0.02 (Fig. 3)

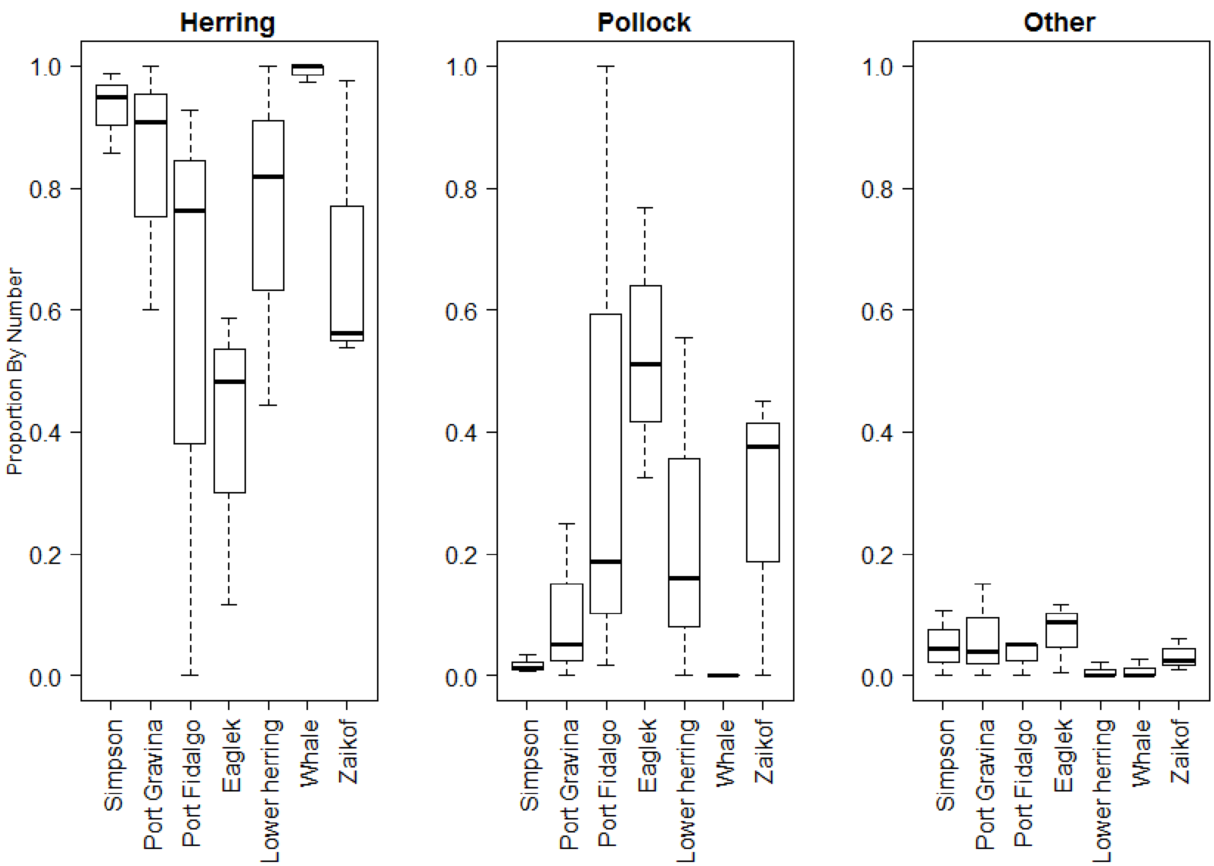

Figure 3. Proportion of herring, pollock and other fishes captured in midwater trawls in each bay or small fjord surveyed in this study during 2013-2015. The dark lines represent the median over the four years of study, the box represents the 25th and 75th percentile of the distribution, and the whiskers represent 1.5 times the inter-quartile range.

Table 1. Summary of acoustic survey area, densities and biomass of juvenile herring (<150 mm TL). Data presented are means of 4 years of surveys (2012-2015) conducted around the new moon in early November of each year. The standard deviation of density across the years of the survey is included in parentheses.

Bay/Small Fjord	**Survey Area (km^2)**	**Density Estimate (herring km^{-2})**
Simpson	11.3	261,135 (133,397)
Gravina	34.4	121,625 (88,248)
Fidalgo	36.1	168,738 (125,945)
Eaglek	16.4	110,664 (101,580)
Lower Herring	5.3	74,549 (88,933)
Whale	9.9	343,223 (389,738)
Zaikof	16.3	93,328 (95,409)

We report results from four cruises with surveys of seven bays for a total of 28 separate acoustic surveys. The area acoustically surveyed ranged from 9.9-36.1 km^2 (Table 1). The mean density of juvenile herring over the four years was highest in Whale Bay, and lowest in Lower Herring Bay (Table 1). Whale Bay also showed the highest inter-annual variance (113% coefficient of variation across the 4 years). The highest density of juvenile herring during a given night survey was observed in Whale Bay in 2014 (909,465 herring km^{-2}). The lowest densities of juvenile herring were observed in 2013 in Fidalgo (nil, based on a lack of herring in trawl catches), Eaglek (95 herring km^{-2}) and Lower Herring (585 herring km^{-2}). The main effect of bay was not found to be significant, but we did observe a significant effect of year (Figure 4). Results indicate that juvenile herring abundance (fish km^{-2}) was significantly lower in 2013 compared to all the other years of the survey ($p=0.01$). Herring densities observed during 2012 were significantly greater than 2013 ($p=0.01$) and 2013 was found to be lower than 2014 ($p = 0.03$) and 2015 ($p = 0.03$). Density outliers (evident in Fig. 4) include Zaikof (low) and Simpson (high) in 2012, and Whale (high) in 2014.

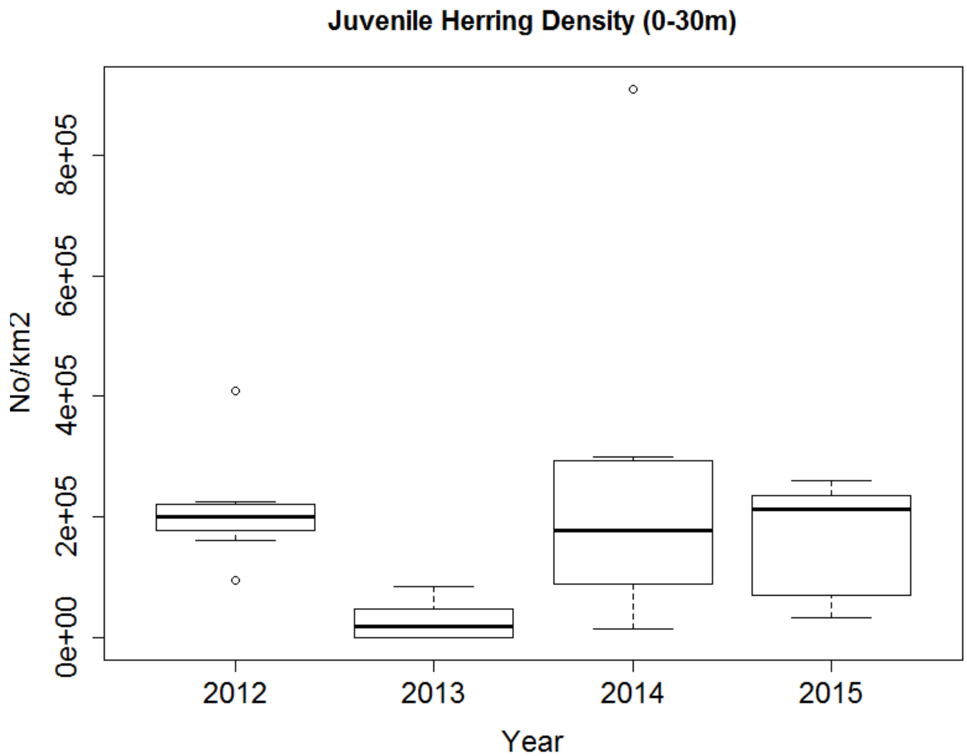

Figure 4. Acoustic estimates of juvenile herring density (number km^{-2}) in the surface layer (0-30m) in the seven Prince William Sound bays and small fjords in this study. Outliers are described in text.

Out of a total of 28 separate regressions of density across the main axes of each bay (7 bays by 4 years), we discovered 25 (or 89%) of regressions were significant, and all but six were positive, indicating higher fish densities in the inner bays. Higher densities in the outer bays were observed in Eaglek in 2012, 2014, and 2015, Simpson in 2013, and Fidalgo in 2014 and 2015.

Sensitivity Analysis of Depth Threshold

Densities estimated in the survey bays responded differentially to changes in the depth thresholds. By adjusting the depth threshold up to 20 m, the juvenile herring density declined by 27.6 % (overall mean of 7 bays), while adjusting the depth threshold down to 40 m resulted in an increase in density of 28.1% (overall mean of 7 bays). This suggests that, across all bays, densities above and below this threshold was uniform. Results varied by bay, however, with Simpson and Gravina exhibiting higher sensitivity to changes in the depth threshold (± ~50%), while the densities estimated in the other bays appeared to be more robust to changes in this threshold (± ~20%). One exception was in Zaikof Bay, where density declined markedly (64.5%) by reducing the depth threshold to 20 m, indicating fish were denser in the 20-30 m depth strata in this bay.

Year was determined to be a significant factor in explaining variation in densities estimated in the survey regardless of the depth threshold applied to the acoustic data (20-40 m). We did observe a smaller p value associated with the effect of year when densities were estimated in the

0-20 m depth strata (p=0.001) when compared to densities measured over the 0-40 m depth strata (p=0.01).

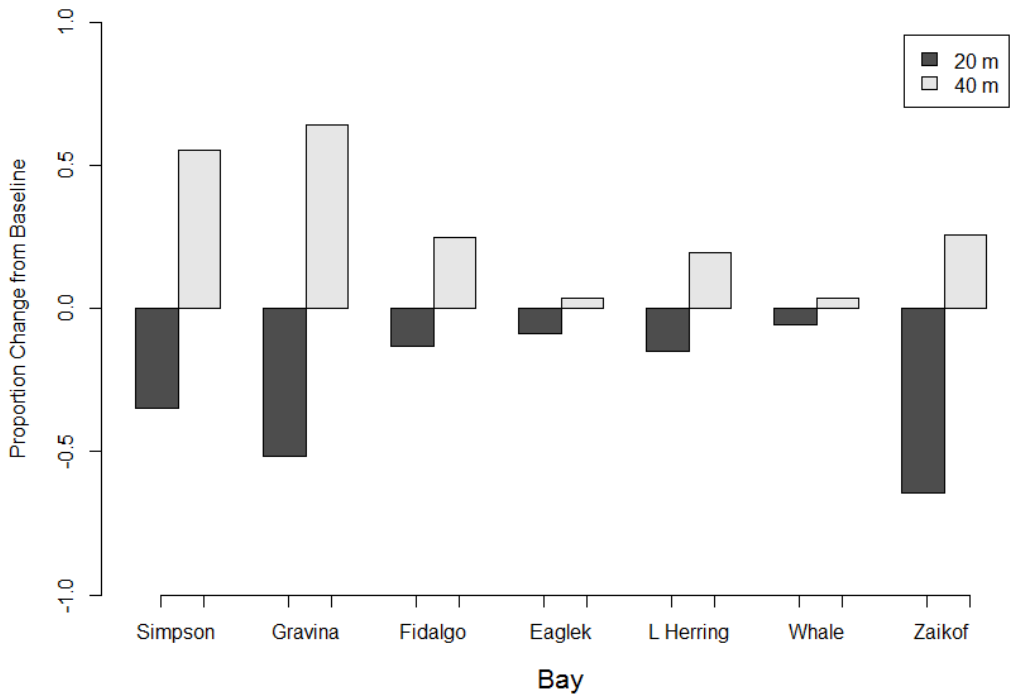

Figure 5. Proportional change in juvenile herring densities after adjusting the threshold depth strata up (to 20 m depth, dark bars) and down (to 40 m depth, light bars). Changes were based on the divergence of mean densities (over the 4 years of the study) from the mean estimates from the nominal run based on an applied depth threshold of 30 m.

DISCUSSION

Combining acoustic surveys and mid-water trawling was an effective method of quantifying juvenile herring biomass in PWS. We found no consistent patterns across bays in terms of contribution to total production of juvenile herring in PWS. The largest overall range of densities and biomass was observed in Whale Bay. Based on isotopic studies of herring, this bay appears to receive the most pronounced oceanic subsidies when the oceanographic conditions favor flux from the Gulf of Alaska into Prince William Sound (Kline 1999; K. Gorman, PWSSC, pers. comm.). Because the strength of this flux is known to vary from year to year, this may help to explain the broad range of densities observed in this bay. Our results suggest a strong year effect, and provide evidence of a weak year class in 2013. We also observed high acoustic backscatter during the fall of 2012 that suggests a strong year class. Biomass estimates during 2014 and 2015 were more variable, and thus we did not observe a significant difference when compared to the earlier years of the study. Others have noted that 2012 was likely a strong year class for juvenile herring (M. Arimitsu, USGS, pers. comm.) and walleye pollock (S. Moffitt, ADF&G, pers.

comm.). Unfortunately, our acoustic surveys that year lacked validation by trawls, and hence our estimates of species-specific densities produced for that year are highly uncertain.

Some recent hydroacoustic observations in PWS bays during November 2015 using an Autonomous Surface Vehicle indicated that fish schools of high density exist in shallow habitat (< 5 m) along the shorelines throughout the inner bays (Zenone and Boswell, FIU, unpubl. data). Juvenile herring are commonly captured in shallow habitat in PWS using beach seines (Johnson et al. 2010) and this habitat may be particularly important for them. Future efforts to describe seasonal patterns in juvenile herring in this ecosystem should adopt a more integrated survey approach that includes sampling shallow as well as deep water habitat.

Our sensitivity analysis indicated that our conclusions are robust to the decision over which depths are considered preferred habitat for juvenile herring. However, we emphasize that the application of this threshold is a source of uncertainty, considering our estimates changed up to 50% based on a 10 m change in the applied depth threshold in our analysis. Advances in acoustic methods to distinguish species (in our case, primarily herring and pollock) may help resolve this issue. Alternatively, a more focused trawl survey, like that described in Stokesbury et al. (2000), that targets different depth strata in PWS could help provide a better means of defining preferred habitat for these species, and ultimately reduces uncertainty in acoustic estimates of density.

Recognizing that the traditional acoustic survey design is not likely surveying all the available habitat, and our current lack of understanding of how juvenile herring move between these habitats, it is difficult to draw any firm conclusions at this point concerning overall population and survival trends. It is important to keep in mind that these are open systems that likely exhibit a high degree of physical and biological flux. It is going to take advances in technology and survey approaches to better understand these dynamics. One of the objectives of this EVOSTC project was to provide a way to index juvenile recruitment to the adult stock to provide more resolution of population dynamics in the ASA model. Our results suggest our survey approach is capable of detecting strong and weak juvenile year classes, but we suggest further development of survey approaches are required. Based on result of an allied project (15120111- G) there is a high level of variance of density estimates between cruises during a given season, suggesting future surveys will need to spread sampling effort across a longer time period to characterize the status of juvenile herring. There is clearly a need to devise a sampling approach that can provide early, independent measures of year class strength to help predict future recruitment to the older age classes of herring in PWS as has been investigated in other systems (Schweigert et al. 2009).

CONCLUSIONS

Combining acoustic surveys and mid-water trawling was an effective method of quantifying juvenile herring biomass in PWS. Results of our index survey suggest that there are no consistent patterns across bays in terms of contribution to total production of juvenile herring in PWS. The largest overall range of densities and biomass was observed in Whale Bay. Our results suggest a strong year effect, and provide evidence of a weak herring year class in 2013. We also observed high acoustic backscatter during the fall of 2012 that suggests a strong herring year class. In future surveys, we recommend expanding effort to include shallower habitats (<5 m depth) and additional research efforts to understand movements of juvenile herring in and out of bays during a broader, seasonal cycle.

ACKNOWLEDGEMENTS

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