Exxon Valdez Oil Spill
Restoration Project Final Report

Coordination and Planning For Herring Research

Restoration Project 00374
Final Report

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<u>Study History:</u> Restoration Project 00374 "Coordination and Planning for Herring Research" was a one-year funded project to conduct a workshop to identify important questions that remain about herring and questions that can and cannot be answered. An EVOSTC 1999 Herring Workshop was held in Anchorage, AK 15-16 November and hosted by Bob Spies, Chief Scientist and Phil Mundy, Science Coordinator. The objective of the workshop was to address the following questions: 1.) What are the elements of the monitoring and research program for the next two years, and for the 21st century? 2.) How can EVOSTC best collaborate with scientists in other agencies and the university to serve the public interest in herring management? and 3.) What is the role of herring in the ecosystem, and the place of this species in an ecosystem monitoring and research program?

The 1999 Herring Workshop was very rewarding scientifically and confirmed that excellent research has been conducted and that more needs to be done. Most researchers agreed that additional research and monitoring needs to be done. Another workshop was necessary to finish discussion of the above objectives as well as discuss new ideas and research goals. The general consensus seemed to be that there is much information about data already collected that needs to be analyzed and that the various components need to be synthesized. A science plan needed to be generated for future herring funding under EVOSTC.

<u>Abstract:</u> All aspects of past research were evaluated and two herring workshops were conducted in February and November 2000 in Anchorage. The objective of the first workshop was to discuss ideas for additional herring research and monitoring. Results of the February workshop and writings were analyzed and "Key Research Questions for Pacific Herring" were formulated. Two manuscripts were completed, "A synthesis of the life history and ecology of juvenile Pacific herring in Prince William Sound, Alaska" (In press, *Fisheries Oceanography*) and. "Estimation of first year survival of Pacific herring from a review of recent stage-specific studies" (In press, Alaska Sea Grant *Herring 2000*). Short and long term recommendations for research priorities for herring were identified from the synthesis manuscripts, the key research questions and discussions with scientists. These documents and priorities were presented to the researchers for discussion at the November workshop. During the November workshop scientists discussed research directions for the future and decided on a single project to be funded in FY01.

<u>Key Words</u>: *Clupea pallasi*, herring, synthesis, research, priorities, future

<u>Project Data</u>: none

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Executive Summary

Much research on Pacific herring was conducted under EVOS funding between 1989 and 2000. This research included a variety of projects, scientists, agencies and objectives. EVOS recognized the need to bring these researchers together to discuss commonalties and to future goals. Three workshops were held to accomplish this. The first was in November 1999, and provided the impetus for this current project. At that workshop it was recognized that compiling and synthesizing information on herring research was not a simple or quick task. Therefore, I was given the assignment of synthesizing herring research, identifying key research questions, and holding an additional workshop. The synthesis of juvenile herring life history can be found in two manuscripts (Appendices I and II). The key research questions were identified as:

1. What is the stock structure of herring in PWS, in the Gulf of Alaska, or in the North Pacific?
2. Why do herring spawn where they do?
3. What causes variability in herring recruitment?
4. What is the role of herring in the ecosystem?
5. How can population size of herring be predicted?
6. What methods can be developed to answer these questions?
7. What tools can be developed to investigate ecosystem relationships?

A second herring workshop was held in Anchorage in February 2000. The discussion of research questions a topics resulted in the formulation of short and long term research priorities for herring. The short-term research priorities are: (1) synthesize within and across projects; (2) analyze data and samples that have already been collected; (3) expand on current/past research; and (4) limited monitoring. The long-term research priorities were numerous and could be grouped in several categories divided somewhat by life stage: spawning, larvae/juveniles, predation, stock structure, disease, biomass/density, and monitoring. Specific research project are listed under both the short- and long-term priorities within this document.

The workshops were a success and yielded excellent ideas for future, cooperative research on Pacific herring. In addition to the projects listed under the short and long term priorities, there was much discussion and support among the scientists for the need for models of various forms. The scientists would like to see EVOS support and fund the projects that were identified. On an immediate time scale, a decision was made about what to fund for herring research in FY01 (Appendix IV).

Introduction

Pacific herring inhabit continental shelf regions and spend much of their lives nearshore (Carlson, 1980; Hay, 1985; Tanasichuk *et al.*, 1993). In late March and early April each year, schools of adult herring begin to migrate from within and outside of Prince William Sound (PWS), Alaska (Figure 1) toward spawning beaches in PWS (J. Wilcock and F. Funk, personal communication, ADFG unpublished data, Juneau AK). Spawning begins by mid-April and lasts from five to 21 days. The spawning of herring in PWS is a massive ecological event attended by large aggregations of gulls, shorebirds, humpback whales, and Steller sea lions. Embryonic herring incubate in intertidal and shallow subtidal areas for 22-24 d at ambient temperatures in PWS (Biggs and Baker, 1993, Brown *et al.*, 1996) prior to hatching in May. Though not documented in PWS, pelagic larvae of herring in other Alaskan locations are retained in nearshore nursery areas by local currents (McGurk *et al.*, 1993). During the spring in PWS, adult spawning herring and their offspring are vulnerable to predation, weather patterns, ocean conditions, and human activities.

On 24 March 1989, the tanker vessel *Exxon Valdez* spilled 42 million liters of crude oil after grounding on Bligh Reef in northeastern PWS (Figure 1). From 1 to 20 April 1989, herring spawned over 158 km of shoreline in PWS (Brady, *et al.*, 1991). Injury to the PWS Pacific herring population from the *Exxon Valdez* oil spill was difficult to evaluate because little was known about early life stages (Brown *et al*., 1996). However, morphologic and genetic damage to larvae and reduced larval growth rates were observed in 1989 (Norcross *et al*., 1996). It became readily apparent that we could neither assess the impact of the spill on juvenile herring nor understand processes affecting recruitment and restoration of the severely reduced herring population in PWS. The Sound Ecosystem Assessment (SEA) project initiated an integrated, multi-investigator approach in 1995 that continued through spring 1998. Its purpose was to identify impediments to recruitment during early life history stages of Pacific herring.

The effects of food availability and water temperature on larval Pacific herring growth rates and larval stage duration were investigated using a coupled biophysical model for 1993 through 1997. The herring growth model included feeding gains, metabolic costs, and mortality losses and allowed for vertical migration of the herring larvae. Interannual differences in larval herring growth and survival rates were due to differences in food availability or water temperature. Larval herring growth rates were determined by bottom-up and top-down processes. Food availability rarely limited larval growth rates. Interannual differences in survival (due to differences in growth rates) were due to differences in water temperature. Vertical migration of herring larvae was occasionally restricted by strong seasonal stratification, which may bar the larvae from reaching food concentrations sufficient for growth.

Prior to the SEA study, the location of Pacific herring nursery areas in PWS was not known, unlike many North Sea and eastern North America stocks of Atlantic herring (*Clupea harengus)* (Cushing, 1975; Iles and Sinclair, 1982; Sinclair and Iles, 1985). Nearshore areas appear to be important habitat for juvenile Pacific herring in PWS for at least the first year of life (Rounsefell and Dahlgren, 1931). Juvenile herring in British Columbia, Canada, inhabit nursery areas within 1-5 km from shore, often in bays, for up to two yrs (Taylor, 1964; Haegele, 1994; Hay and McCarter, 1997). It has been suggested that the proximity of the shore may provide a form of topographical relief required by juvenile herring (Hay and McCarter, 1997). Therefore, we began by examining the nearshore habitat and factors affecting it in PWS, including transport of larvae to these nursery areas.

A physical circulation model was used to simulate dispersal of herring larvae in Prince William Sound in 1996. The model showed most simulated herring larvae were advected into bays and retained in PWS. The results of this simulation model agree favorably with actual distribution in PWS of herring larvae in 1989 and juveniles in 1996. Simulated larvae originating at all spawning regions were mixed in nearshore nursery areas throughout PWS. The model provided evidence for retention of larvae within the southeast portion of PWS, which may have implications for local competition among juveniles. Other simulated herring larvae, though less than anticipated, were transported out of PWS through Montague Strait. The preliminary model was limited in physical and biological constraints of input data, which should be corrected in updated versions.

In agreement with the simulation model, field studies showed that bays on all sides of PWS were nursery areas for ages-0 and -1 herring, with more larvae retained in eastern PWS bays. Water from the Gulf of Alaska was transported into PWS and contributed oceanic prey species to neritic habitats. Variations in local food availability resulted in different diets and growth rates of herring among bays. Summer food availability and possibly competition in nursery areas affected the fall nutritional status and juvenile whole body energy content (WBEC) differed among bays. The WBEC of juvenile herring in fall was critical to over-winter survival. A limited amount of food was consumed in the winter and was not sufficient to meet metabolic needs. The smallest age-0 fish were most at risk of starvation stresses in winter. Over-winter mortality of age-0 herring was modeled using fall WBEC of herring and winter water temperature. Differences in feeding and energetics were detected among nursery areas during both summer and winter, indicating that habitat quality and resultant survival were not equal in all areas or all years. Habitat conditions in various PWS bays were not uniform in space and time. These conditions were measured by temperature, zooplankton abundance, size of juvenile herring, diet energy, energy source (GOA vs. neritic zooplankton), WBEC, and within-bay competition.

Using the factors affecting survival of herring from spawning through age-0, stage-specific estimates of survival from recent studies were extracted and potential cumulative upper and lower limits of survival were calculated through the first year. Spawn timing, duration, water temperatures, amount, and location may affect survival year-class strength, though no estimates of effect on survival were available. Egg survival is affected primarily by wave action and predation with an estimated survival rate of 24 – 45%. Newly hatched larvae may experience abnormalities, especially of jaw formation, increasing their mortality. Estimated survival for post-hatch herring larvae is 50 – 100%. Starvation, predation and transport contribute to the mortality of later-stage larvae; no two studies of herring obtained the same mortality estimates. Simulation modeling of larval drift in PWS, using a generalized daily mortality rate for herring in the northeast Pacific, estimated loss through mortality and transport out of PWS resulting in an estimated survival of 1 – 7%. From entrance into nursery areas through autumn, food availability, competition predation and disease may affect survival of juvenile herring. Acoustic surveys in PWS estimated relative density of juvenile herring in summer and autumn, resulting in an estimated survival rate to October of age-0 herring of 2-21%. Juvenile herring experience over-winter mortality due to insufficient energy reserves. Conditions vary among nursery areas resulting in modeled estimates of over-winter survival of 5 – 99%. Cumulative ranges for these early life history stages resulted in a potential 3-order of magnitude span in survival estimates of 1 – 6,500 juveniles per 1 million eggs. This compilation identifies the late larval and early juvenile stages as having the lowest potential survival estimates. Furthermore, the wide range of survival estimates for the winter juveniles was related to specific nursery areas.

When strong year classes first appear in the commercial fishery, they are age-3 or -4, i.e., 2–3 years beyond our estimates of survival. While mortality at older ages is generally low compared to that of larvae and juveniles, some factors, such as disease, may be significant. VHSV causes an acute disease, especially in young fish (Marty et al. 1998). It may cause the collapse of a fishery, as seen for herring in PWS in 1993 (Marty et al. 1999) and 1999 or more commonly may significantly limit recruitment (Marty 2000). The disease was prevalent in PWS in 1997 and 1998 (Marty 2000) and affects juvenile survival (Kocan et al. 1997), thus its effect would have been accounted for in the estimates of juvenile survival presented here. However, VHSV also affects older age classes (Marty et al. 1998, Hershberger et al. 1999), an effect not accounted for here. Another disease found in PWS (Marty et al. 1998), caused by the fungus *Ichthyophonus hoferi*, is chronic and decreases the life expectancy of the fish (Marty 2000).

These two diseases are not correlated with recruitment, indicating that their main effect is in the adult stage (Quinn et al. 2000).

The above synthesis of Pacific herring life history was the foundation for discussions, identifications of gaps in knowledge and formulation of research questions and priorities.

Objectives

The objectives of this project were to:

1.) hold another workshop,
2.) layout a series of projects and research questions,
3.) identify priorities,
4.) develop a science plan for future herring research and monitoring,
5.) identify a process for moving forward.

Methods

The first step of this project was to collect all reports, published papers, and proposals, etc. relating to herring research that have been written under EVOSTC funding. to organize a herring workshop in February 2000. These were reviewed and synthesized for discussion at the February workshop. The objective of the second (February 2000) workshop was to go beyond sharing results as in the first (November 1999) workshop, but rather to share new ideas for future research. Specifically the objectives were (1) to develop synthetic or comprehensive ideas that increase our knowledge about herring the ecosystem and as a fishery target, (2) to develop ideas for integrated and cooperative research that overlaps and incorporates our various fields of research, and (3) to provide EVOS with a research plan for herring for the future. The focus of the workshop began with what scientists saw as potential gains from existing data. Researchers were asked to bring ideas for future research to the workshop, including those proposed and funded, proposed and not funded, and not-yet proposed.

After the workshop, existing research was assimilated, evaluated, and incorporated into an integrated picture of herring. These findings were incorporated in the synthesis manuscripts. The outcome of this analysis enabled identification of important questions that remain about herring. Recommendations were produced for short and long term research priorities for herring in the future.

Results

Objective 1. To hold another workshop.

A Herring Workshop was held in Anchorage, AK on 23 February 2000 at the Regal Alaskan Hotel in conjunction with the Herring 2000 Wakefield symposium. The following “Ideas for Future Herring Research” were compiled from comments at November 1999 workshop and proposals, both funded and unfunded, submitted to EVOS. Note the name in parentheses is the person who proposed that idea. These formed the foundation for the discussions held at that workshop. The results of the workshop then formed the basis for fulfillment of the subsequent objectives.

Spawning

Synthesize ADF&G data sets: (Fritz Funk)

- Spawn timing and locations (maps)
- Temperature and timing
- Size at age
- Roe percentage
- Abundance

Study role of habitat in recruitment, i.e., why is not all available spawning habitat used? (Fritz Funk)

Study if timing of zooplankton bloom in relation to herring spawning and hatching matters (Fritz Funk)

Zoogeography questions: why no spawning in herring in Southern California? In Aleutians? In Chukchi? (Fritz Funk)

Do herring home to spawn? What percentage? What effect of homing vs. not homing? (Norcross)

Larvae/Juveniles

Relate change in susceptibility of age-0 herring to VSHV to condition factor (i.e., why do some herring develop immunity and some do not?) Incorporate results into model of juvenile survival (Kocan – unfunded proposal-99)

Determine importance of GoA carbon to herring nursery areas by comparing isotope signatures and species compositions (Paul and Foy – unfunded proposal-99)

Determine physical attributes of nearshore areas that contribute to enhancing or preventing transport of zooplankton into nursery areas (Paul and Foy – unfunded proposal -99)

Competition for food with other species? Incorporate competitors into analysis like Foy’s? (Norcross)

Examine morbidity and mortality in juvenile herring as population-limiting factors that affect spawner/recruitment (Kocan – unfunded proposal -98)

Study the effects of herring spawning location and how larvae are distributed for generalized climate scenarios (using larval drift model) (Norcross – unfunded proposal-99)

Examine small-scale distribution of herring in relation to physical characteristics with nursery areas using data collected in SEA (Norcross – unfunded proposal-99)

Predation

Need some measure of predation on herring (Bob Spies)

Look at Mark Willette's data for salmon predation. (Tom Kline)

Look at other predators on herring. How to measure? (Norcross)

Stock Structure

Scale pattern analysis (James Brady)

Note: Evelyn Brown proposed this to EVOS and was not funded.

Identify discrete stocks of herring in mixed-stock fisheries (Willette et al. – unfunded proposal – 98)

Disease

Study effect of disease by age class (James Brady)

What conditions cause an epizootic (disease that wipes out a population)? (Dick Kocan)

What are effects so diseased herring have on upper trophic levels, i.e., more or less eaten? (Norcross)

Biomass/Density Estimates/Monitoring

Correction of acoustics density estimates for SEA 320T (George Rose)

Retrospective analysis of ADF&G herring ASA (age-structured analysis), i.e., VPA. (George Rose)

Incorporate disease into ASA (James Brady)

Develop ecosystem-based ASA model coupled to physical model (George Rose)

Long term monitoring of herring abundance (James Brady)

Study effect of growth rate on recruitment, i.e., is it related to population size (James Brady)

Know spawning biomass at time of harvest so can do no harm (Phil Mundy)

Know estimate of recruitment by some means other than fishery for long term to advise industry (Phil Mundy)

Predict recruitment to fishery (James Brady)

Need best effort retrospectively to understand past herring populations sizes (Evelyn Brown)

Need index of abundance of herring measured consistently (Nov. workshop)

Need cost-effective sampling for herring index (Bob Spies)

At what life stage should we measure herring abundance? (AJ Paul)

Project weight at age using historical data bases to develop models (Willette et al. – unfunded proposal –98)

Estimate spawning biomass of herring around Kodiak with acoustic and aerial techniques (Willette et al. – unfunded proposal –98)

Investigate if Sitka herring are not at carrying capacity, vs. if PWS herring are at carrying capacity. (Gary Marty)

Oceanographic/Climate Effects

Affect of regime shifts on feeding competition and predation (Beamish and McFarland).

Explain spatially synchronous year classes with oceanography, i.e., inside vs. outside waters. (Quinn)

Oil Spill Effects

Use statistical techniques to see difference in success of year classes in Sitka vs. PWS falls out into pre- and post-spill. (Pete Peterson)

How to sort out effects on herring from 1989 oil from 1988-89 regime shift? (Evelyn Brown)

Still need to understand collapse of herring in 1993, i.e., not agree with Mark Carls that it is unrelated to EVOS (George Rose)

Synthesis

Sensitivity analysis for steps in herring life history modelling, i.e., in synthesis (Pete Peterson)

What life stage is most vulnerable or sensitive? Need sensitivity analysis (Pete Peterson)

(Note: Many of these topics are synthetic across disciplines and not related to the sole topic under which I categorized it.)

Objective 2. To layout a series of projects and research questions.

Key Research Questions for Pacific Herring

1. What is the stock structure of herring in PWS, in the Gulf of Alaska, or in the North Pacific?

    How does stock structure affect management strategies?
    How does stock structure affect sustainable use?
    Should we be considering “metapopulations”? How?
    Is it necessary to maintain biodiversity of stocks?

2. Why do herring spawn where they do?

    Is there fidelity (homing) to a spawning site?
    Why are some areas used consistently?
    Why are some areas used only sporadically or occasionally?
    Does temperature affect where they spawn?

3. What causes variability in herring recruitment?

    What life stage is most vulnerable? (See Norcross et al., In review)
    What are the oceanographic influences?
    What are the climatological (e.g., regime shift, PDO, El Nino) influences?

4. What is the role of herring in the ecosystem?

    As a commercial fish?
    As a forage fish?
    As a predator?
    What is the carrying capacity of a specific ecosystem for herring?

5. How can population size of herring be predicted?

    At what life stage should herring population be monitored?
    Is there a relationship between spawning population size and number of recruits.

7. What methods can be developed to answer these questions?

    How do we monitor population size?
    Field techniques?
    Remote sensing techniques?
    Statistical analyses?

7. What tools can be developed to investigate ecosystem relationships?

    For integration of more than one life stage into models?

For incorporation of more than one factor into models?
For comparisons across space and time?

Objective 3. To identify priorities.
Objective 4. To develop a science plan for future herring research and monitoring.
Objective 5. To identify a process for moving forward.

The results of Objectives 3, 4 and 5 are intermingled. Those results follow below and also are found in in the Norcross et al. manuscripts (Appendix I, Appendix II, and Appendix III).

Recommended Short Term Research Priorities for Pacific Herring in PWS

The following is a list of priorities that should be addressed immediately (i.e., within a year, two at the most) regarding herring in PWS. Addressing these needs will provide a foundation for future research as envisioned by GEM. Following the description of each priority is a list of some projects that could be undertaken.. These projects are not listed in order of priority. The names in parentheses are the people who suggested or previously proposed this idea.

1. Synthesize within and across projects

There is presently a huge body of collective knowledge regarding herring in PWS. Unfortunately, most of it currently exists in many diverse projects. There have been some efforts at synthesis at least for some life stages (e.g., Norcross et al. In press, Norcross and Brown In press, In review, Brown In prep). The synthesis work that has taken place thus far exists within SEA. However, even those reviews are not comprehensive in that additional work has been completed that could be incorporated in those syntheses. There are quantities of research on herring outside of SEA that should be incorporated and analyzed in a comprehensive manner. The individual projects produced excellent results, but the ecological break insight will come from an integrated approach that links life stages. This is a cost-effective approach with a likelihood of producing significant results. This may include modeling projects that join life stages.

Suggested Projects:

Synthesize ADF&G data sets: (Fritz Funk)
Spawn timing and locations (maps)
Temperature and timing
Size at age
Roe percentage
Abundance

Incorporate disease into ASA (James Brady)

Need best effort retrospectively to understand past herring populations sizes (Evelyn Brown)

Affect of regime shifts on feeding competition and predation, like Beamish and McFarland (Norcross).

Explain spatially synchronous year classes with oceanography, i.e., inside vs. outside waters. (Quinn)

Use statistical techniques to see difference in success of year classes in Sitka vs. PWS falls out into pre- and post-spill. (Pete Peterson)

How to sort out effects on herring from 1989 oil from 1988-89 regime shift? (Evelyn Brown)

Still need to understand collapse of herring in 1993, i.e., not agree with Mark Carls that it is unrelated to EVOS (George Rose)

What life stage is most vulnerable or sensitive? Need sensitivity analysis for steps in herring life history modeling, i.e., in synthesis (Pete Peterson)

Integrate and synthesize results of SEA, APEX and NVP.
Fund workshop to get an exchange of ideas started.

2. Analyze data and samples that have already been collected.

So many samples and so much data were collected over 5-7 years that yet not all analyses have been completed. While original contract obligations have been met, additional samples or data often were collected and not analyzed. Additionally the research process itself generated new hypotheses that could be tested with the samples and data that exist. This is a unique and cost-effect opportunity to produce more information about herring in PWS. These results would then add more information to the synthesis efforts. Simulation modeling is one tool that could be used to reanalyze data.

Suggested Projects:

Study if timing of zooplankton bloom in relation to herring spawning and hatching matters (Fritz Funk)

Determine importance of GoA carbon to herring nursery areas by comparing isotope signatures and species compositions (Paul and Foy – unfunded proposal-99)

Determine physical attributes of nearshore areas that contribute to enhancing or preventing transport of zooplankton into nursery areas (Paul and Foy – unfunded proposal -99)

Study the effects of herring spawning location and how larvae are distributed for generalized climate scenarios (using larval drift model) (Norcross – unfunded proposal-99)

Examine small-scale distribution of herring in relation to physical characteristics with nursery areas using data collected in SEA (Norcross – unfunded proposal-99)

Correction of acoustics density estimates for SEA 320T (George Rose)

Retrospective analysis of ADF&G herring ASA (age-structured analysis), i.e., VPA. (George Rose)

Project weight at age using historical data bases to develop models (Willette et al. – unfunded proposal –98)

Analyze/utilize Carlson's data. (Brandee Gerke)

3. Expand on current/past research

Herring researchers generated many new hypotheses about this species over the course of 5 – 7 years. In many instances, a small amount of field work could fill in gaps in past research allowing many of the new hypotheses to be tested.

Suggested Projects:

Study role of habitat in recruitment, i.e., why is not all available spawning habitat used? (Fritz Funk)

Relate change in susceptibility of age-0 herring to VSHV to condition factor (i.e., why do some herring develop immunity and some do not?) Incorporate results into model of juvenile survival (Kocan – unfunded proposal-99)

Examine morbidity and mortality in juvenile herring as population-limiting factors that affect spawner/recruitment (Kocan – unfunded proposal -98)

4. Limited monitoring

While it was time to stop large-scale sampling projects and focus on analyzing data that had been collected, EVOS may have done themselves a disservice by discontinuing all sampling. For example, there was no sampling for juvenile herring in summer 1997 and 1998. This could have provided valuable information about the effects of El Nino. Some very focused, limited monitoring should be conducted as a stop-gap measure before a new monitoring program can be designed.

Suggested Project:

Need index of abundance of herring measured consistently (Nov. workshop).

Recommended Long Term Research Priorities for Pacific Herring in PWS

Consensus Projects

Sampling for larval fishes, herring and competitors
- May answer if PWS is a closed population
- Sound-wide plankton watch, community involvement
  - Involve high schools, mount passive collectors
- Must also sample outside of PWS
- Measure larval loss

Stock structure – endorsed tentatively as pilot study to test feasibility
- Methods
  - Coded wire tags
    - Jake Sweigart will soon have data to know if this works in BC.

Fatty acid signature (Otis 98 proposal) – Hay has tried and this does not work; reflects food; changes with season.
- Elemental otolith signature.
- Scale pattern recognition
- Objectives
  - Open vs. closed population question
  - Knowledge regarding discreteness of stocks to guide management
    - Know geographic range to use when calculating exploitation rates
  - Examine ‘homing’ in herring, i.e., site fidelity for spawning

Spawning

Zoogeography questions: why no spawning in herring in Southern California? In Aleutians? In Chukchi? (Fritz Funk)

Do herring home to spawn? What percentage? What effect of homing vs. not homing? (Norcross)

Larvae/Juveniles

Study disease in juvenile herring to understand prevalence, variability, and effect.

Competition for food with other species? Incorporate competitors into analysis like Foy’s? (Norcross)

Combine herring larval drift model (Wang, et al.) with larval growth model (Thornton et al.) (Norcross)

Predation

Need some measure of predation on herring (Bob Spies)

Look at Mark Willette’s data for salmon predation. (Tom Kline)

Look at other predators on herring. How to measure? Design ways to sample. (Norcross)

Stock Structure

Scale pattern analysis (James Brady)
Note: Evelyn Brown proposed this to EVOS and was not funded.

Identify discrete stocks of herring in mixed-stock fisheries (Willette et al. – unfunded proposal – 98)

Disease

Study effect of disease by age class (James Brady)

What conditions cause an epizootic (disease that wipes out a population)? (Dick Kocan)

What effects do diseased herring have on upper trophic levels, i.e., more or less eaten? (Norcross)

Biomass/Density Estimates/Monitoring

Develop ecosystem-based ASA model coupled to physical model (George Rose)

Long term monitoring of herring abundance (James Brady)

Study effect of growth rate on recruitment, i.e., is it related to population size (James Brady)

Know spawning biomass at time of harvest so can do no harm (Phil Mundy)

Know estimate of recruitment by some means other than fishery for long term to advise industry (Phil Mundy)

Predict recruitment to fishery (James Brady)

Need cost-effective sampling for herring index (Bob Spies)

At what life stage should we measure herring abundance? (AJ Paul)

Estimate spawning biomass of herring around Kodiak with acoustic and aerial techniques (Willette et al.–unfunded proposal –98)

Investigate if Sitka herring are not at carrying capacity, vs. if PWS herring are at carrying capacity. (Gary Marty)

(Note: Many of these topics are synthetic across disciplines and not related to the sole topic under which I categorized it.)

Discussion

The three herring workshops that were held included an initial one in November 1999, and two organized by this PI, one in February 2000 and another in November 2000. The workshops were very successful in that they provided a forum for scientists working on herring to discuss the results of their science and begin to think beyond their research. These workshops provided the first opportunity under EVOS for a small discussion setting involving scientists funded on seemingly unrelated projects. It was enlightening for the individual scientists to see how their work fit into the larger, ecological framework.

There was agreement among the scientists attending these workshops that there is much research yet to be done on Pacific herring in general, and in Prince William Sound in particular. The ideas for short term and long term research outlined in the results are compilations of these discussions. There was no descent expressed for any of the ideas in the priorities included in this document. The scientists expressed concerns that the priorities listed be adhered to by EVOS and in the future by GEM.

At the end of the third workshop (November 2000) there was much discussion about the need for and value of models. Not everyone had the same opinion of what a model is or how it should be structured. Everyone did agree that the objectives of the model must be made clear at the outset, they just did not agree on what the objectives for a model should be. Some comments indicated that a model that contributed to knowledge of the ecology of herring and its role in the ecosystem was the goal. Others considered the goal to be a predictive model for use with the commercial fishery. There was a consensus about the need for stage-specific considerations and linkage across stages. At the end of the third workshop when Bob Spies asked the question “What should we do right now?” the discussion turned to how to shape a model. There was no agreement on the form of the model, the types of data to be included or the objectives. There was agreement that this should be worked on, perhaps by a small group.

However, when Molly McCammon got more specific and asked “What could be done right now for $100 K?” that changed the tenor of the discussions. Modeling was still agreed upon, though most did not think $100 K could do more than answer the question about what form the model should take. Therefore it was suggested, and subsequently agreed up by EVOS, to immediately fund ADF&G to work on ASA (Age-Structured Analysis) hindcasting, a pilot study using lipids to differentiate stocks, and additional aerial surveys for monitoring (Appendix IV).

Conclusions

I conclude from these efforts to coordinate herring research in PWS, that the herring researchers are very interested in cooperating and working with each other. The scientists were in agreement with the priorities identified and expressed an interest in seeing EVOS acknowledge these priorities. Furthermore, the scientists would like to have opportunities to continue to work on herring research in PWS and, importantly, in a more comprehensive and cooperative manner than was possible under the time and funding constraints in the past.

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