HCRS Herring Disease Seminar and Workshop

Four Points by Sheraton Vancouver Airport, Richmond, B.C.
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Summary and Notes

Background

Herring fisheries have occurred for more than a century on most coastal areas of the northeast Pacific, from California to Alaska. There was a sharp coast-wide decline in nearly all herring populations in the mid 1960's. Fisheries were closed and all populations subsequently recovered rapidly. In most coastal areas herring fisheries for sac roe and spawn on kelp started in the early 1970's. Although the earliest fisheries were frantic and poorly managed, a cautious, conservative management system was soon developed and implemented in most areas. In general the management system and associated support by the fishing industry and the research community have received favourable reviews from all sectors.

In recent years several herring populations have declined and have not recovered, even in the absence of active fishing. One population that collapsed suddenly in the early 1990's, was in Prince William Sound Alaska, three years after the Exxon Valdez oil spill. This collapse was followed by intense research on all aspects of herring biology and population dynamics. Following the spill, an exceptionally high incidence of disease was noted in the population. A possible implication is that disease might have been the factor that led to the rapid collapse of the population, and perhaps also a factor preventing the recovery of the population.

In Canada, herring populations in Queen Charlotte Islands that spawn mainly in Juan Perez and Skincuttle inlets also declined, at roughly the same time and to the same extent as the Prince William Sound herring. Also, herring in several other locations have not fared as well as expected, including herring stocks in Barkley Sound. Some of the areas where sharp declines occurred had a history of spawn-on-kelp operations. Research on fish disease in general, and herring in particular, indicates that impoundment operations (which may crowd and stress fish), may lead to increased prevalence of disease.

Introduction

The objectives of the workshop were simply to determine what we know, what we do not know and what we should know about disease in herring. The workshop was attended by about 20 people representing DFO fisheries management and research, HCRS directors and several consulting biologists working in herring research.

Lorena Hamer opened the meeting and explained the background for the meeting, including the interest in the topic by the Herring Conservation and Research Society (HCRS). Vivian Haist, Lorena Hamer, and Doug Hay chaired the sessions. The presenter was Dr. Paul Hershberger from the Marrowstone Marine Field Station, Western Fisheries Research Center, United Stated Geological Service (USGS), in Norland, Washington state. This summary of the workshop was prepared by Doug Hay, Vivian Haist and Lorena Hamer on behalf of the HCRS. Although we attempt to provide a full but concise synopsis of the workshop, this summary may not necessarily reflect the full range and emphasis of topics that were presented and discussed.

The main conclusion from the presentations and discussion is that much more is known about herring diseases than many of the participants realized. There also are some substantial gaps in our knowledge. The potential role of disease as a factor to consider for management is substantial, particularly for management of impoundment fisheries that result in stress to fish. Other anthropogenic factors such as oil spills, and perhaps some fish farm operations may also affect the incidence of disease. Similarly, disease might be transferred from wild herring to farmed fish. There was general agreement at the conclusion of the workshop that further research on disease is essential. It is especially important to begin to monitor the incidence of disease in wild BC herring populations.

Presentation 1(morning)
Ecology of Diseases in Wild Fish Populations

Disease and Population Abundance

There is increasing evidence that disease may be an important part of ecosystems in general and dynamics of fish populations in particular. Clupeid fishes such as herring are notorious for fluctuations in abundance, and it is well known that in Pacific sardines these fluctuations have occurred for thousands of years, prior to any commercial fisheries. It also is established that most disease organisms occur naturally and have co-evolved with host species over millions of years. There is interesting recent evidence that the experimental removal of a parasite stopped a fluctuation in population numbers that occurred in infected populations. The implication is that disease and parasites could have a major role in the regulation of abundance of wild populations, such as herring. It has been established that intense outbreaks of viral disease in Australian sardines led to severe epidemics that in turn led to population crashes. It is not clear if the same phenomenon can occur in Pacific herring, but it seems very likely.

Pacific Herring are Affected by Multiple Diseases

Three diseases are important in Pacific herring. Two diseases are viral: *Viral Erythrocytic Necrosis* or (VEN) and *Viral Hemorrhagic Septicemia* (VHS). The third disease is a protozoan parasite (sometimes erroneously called a fungus): *Ichthyophonus.* All three diseases are currently considered endemic throughout the NE Pacific.

VEN epizootics were first reported in the Puget Sound region. VEN outbreaks occurred regionally within Puget Sound and did not correspond with outbreaks in other areas. VEN epizootics persisted for extended periods. Epizootics were not accompanied with observed mass mortalities but in one location (Skagit Bay) affected cohorts eventually disappeared.

VHS also appears to be ubiquitous and geographically widespread in herring and other species, such as Pacific sardine. Although monitoring of the disease prevalence has been limited, it appears in most Pacific herring populations but does not necessarily develop into a virulent disease. When virulence does develop it may cause the fish to break out in external lesions and lead to instances of mass mortality. Such occurrences are common in Pacific sardine, but less frequent in herring. VHS appears to become virulent when herring are stressed, and the disease has been noted in juveniles following small oil spills, and in ponds, where herring are confined at high density and stressed. Not all infected herring are necessarily in poor health and some herring can acquire immunity to this disease. This makes it difficult to assess the prevalence of the disease in wild populations. However, assay techniques under development may make it possible to determine the frequency of fish that have such immunity. This is important, because VHS can, on occasions lead to severe disease outbreaks and may have a very significant role in the determination of herring population size and age structure. (More information on this disease was presented in the second presentation, summarized below).

Ichthyophonus might affect Pacific herring population size and age structure. The organism is ubiquitous, the prevalence increases with age of herring and it is highly pathogenic. It appears to be more frequent in older individuals and may make them more susceptible to predation, with the consequence that the median age of the population declines. It is known to be associated with epizootics in Atlantic herring.

Summary of Key Questions and Discussion from Presentation 1

- *Does the influx of sardine into BC in summer (200,000 - 300,000 t since mid 1990's) potentially introduce or increase disease potential for herring?* Die offs (in fall) have included both herring and sardines. They have similar diseases, and it is not clear if transfer is in a particular direction.

- *Should more monitoring be done?* Baseline data is important, so that we know when conditions are different. For VHS, maybe we should be looking at previous exposure, rather than current prevalence.

- *Is disease an issue in juvenile mortality (i.e. a year-class not developing)?* Is this a potential issue for the St. of Georgia 2005 cohort? (There is some indication of this happening in Puget Sound, perhaps due to VHS.) We have seen herring die-offs in BC (generally in November to March), due to disease. This often occurs in heads of inlets, which have cold water and little food.

- *How widespread is VEN and is it lethal in herring?* The virus has been known since 1970's. It is reported periodically, but there is not a routine test done in labs.

- *How specific are these diseases to other fish species?* Ichthyophonus is widespread across marine fish species; VHS occurs throughout the NE Pacific, especially in pelagic species, but also occasionally in salmonids. Genetic typing suggests herring transfer VHS to Atlantic salmon in net pens. Other VHS types occur on the east coast. Recently a different genetic type has moved into the Great Lakes. VHS has the capacity to go into a wide range of species. The virus can be extremely durable, which facilitates water borne transmission (The virus can live 1 year or longer in fresh water; not as long in salt water. The virus is temperature dependent – it can survive 2 wks at 10 degrees.)

- *Industry concern is potential issues that stocks with no fishing (QCI & WCVI) are not recovering – are SOK or salmon farms and disease transmittance a potential reason for this?*

- *Can viral shedding continue after mortality... do carcasses shed virus*? Dr. Hershberger is interested in this question, and has tried (unsuccessfully) to address it experimentally in the past. Work will continue to pursue this question. There is an indication from other sources that suggests dead fish may continue to shed virus.

- *Some people believe that large mortality events (i.e., that might occur in some SOK, operations, or accidental loss during commercial fisheries) can "sour" grounds so that herring do not spawn in location in following years. Is disease a possible cause of such souring?*

Presentation 2 (afternoon)
VHSV Shedding from Pacific herring: Implications for Spawn-on-Kelp Fisheries

When wild herring from Puget Sound were captured and held in captivity the frequency of VHS infected individuals increased in the tanks and the mortality of infected herring increased sharply. Tests with clean, laboratory raised herring that had never been exposed to VHS showed that once exposed and infected, viral shedding started after 4 - 6 days and peaked 6 - 10 days post-exposure.

Onset of viral shedding preceded the onset of mortality by 2 days. The prevalence of VHSV declines with herring age which suggests that some fish may acquire some immunity.

VHS has been examined in detail in Alaskan spawn-on-kelp ponds in Prince William Sound (PWS) and other herring impoundments in Puget Sound. In that population high incidences of VHS occur and the Alaskan Dept. of Fish and Game include a disease incidence factor (VHS) in their stock assessment models. It is clear that impoundments in SOK operations can lead to higher incidence of VHS within ponds. It also seems clear that the virus can spread among ponds through viral shedding. It is probable that high rates of shedding in pounds have the potential to infect wild fish. For example, empirical studies indicate that viral shedding from infected herring is substantial, with a single herring shedding approximately 5×10^8 virus particles per day. When extrapolated to the scale of impounded herring, these results suggest that approximately 10^{14} virus particles / day are shed by diseased herring in a single impoundment. When diluted equally over a large water mass like Puget Sound (26.5 mi^3), this amount of VHSV would result in 1 virus particle / liter of Puget Sound water, Viral production is substantial. Although it is certain that SOK operations can lead to higher incidence of VHS in herring within ponds, it remains to be established that SOK operations can affect entire populations, and if so, how great can the effect be. It is clear, however, that younger herring are more susceptible to the disease than older fish.

There is much to be learned about VHS and herring. For instance, it is not clear if a low - level shedding by infected fish continues after the epizootics waned. It is not clear if herring surviving epizootics can be carriers of the virus. Also, it is not clear if there is minimum exposure levels required to start epizootics in larger schools of herring.

Summary of Key Questions and Discussion from Presentation 2

- *Are there differences between immune and naive herring in size-at-age or other factors?* Juvenile survivors of an epizootic can have skeletal deformities that can affect later survival. This is not evident for larger fish.

- *Can disease outbreaks cause risk to consumers?* Dr. Hershberger is not aware of any evidence that herring diseases that can be transmitted to mammals.

- *Why wouldn't every fish be exposed to VHS (given the potential quantity of VHS in environment)?* Some fish may be immune or have acquired immunity from an earlier, but non-lethal exposure.

- *Is there potential for ongoing affects from SOK operations?* Prince William Sound SOK has been closed for many years, and populations are not recovering. If VHS were preventing recruitment (and VHS came from SOK impoundments) we would expect recruitment would return to normal 1-2 yrs after removal of impoundments.

- *DFO management strategy when reopening closed areas is to re-establish SOK as first fishery after reopening... If disease a key issue in demise of this stock, is that a reasonable approach? Should DFO be developing policies around this?* Impoundments and VHS have a complex relationship. There can be an epizootic with and without impoundments; there can be impoundments without epizootic. But, epizootics are more common in impoundments, and handling fish in impoundments is critical.

- *Is it possible for disease to transfer from salmon to herring?* An example of transference from sardines to salmon in net pens occurred in Puget Sound. The diseased fish were transferred, and the disease was transferred with them. We have discussed disease transfer in herring SOK and

bait pounds, but the same potential is there with salmon farms (especially because salmon farms often have lights on which attracts herring into pounds).

Presentation 3 (afternoon)
Development of Strategy, Research and Policy Regarding Herring Disease

Summary of Key Discussion Points from Session 3

Knowledge of the natural levels of disease in populations is required before the effect of other factors, such as impoundments can be examined. A fundamental problem is that there are no clear guidelines as to what type of monitoring might be required for an adequate baseline survey. Assessing baseline levels in relatively pristine areas where there are no impoundments, or other potential factors (such as chronic pollution leading to stress) that might affect disease rates, may be appropriate for initial baseline monitoring. However, there are also other empirical research questions related to disease transfer, disease recovery and disease resistance that could be addressed as complementary research activity, supporting baseline surveys. To this end, the Marrowstone laboratory has the unique capacity of raising certified pathogen free stocks that could be used for this research.

Important Questions Raised in This Morning's Session:

- *What is the natural role of disease in populations*? Disease organisms in herring are naturally occurring. Depending on the disease organisms, however, a low rate of infection does not necessarily represent a problem or special concern for stock assessment or management. There is a concern, however, that when disease rates become high, there may be higher rates of mortality, perhaps even age- or size-specific mortality that may go unnoticed and have the effect of confounding assessments.

- *What is the role of impoundments for disease*? The role of impoundments on disease remains uncertain, but there is cause for suspicion that intense impoundment activity might lead to amplified disease rates and lower spawning stock biomass in surrounding areas.

- *What disease research on herring is DFO currently doing*? While the focus of DFO disease research is not specifically on herring, DFO is collaborating with Paul Hershberger in continuing to develop tools to study disease. DFO science staff also are responding to mass-mortality or "die off" events, and attempt to identify and analyzing the nature of the disease involved.

Summary Remarks

This workshop was successful. It made participants aware that disease is a complex but important issue. It also became clear that collaborative work and connections between people working on fish disease (whether from Alaska, British Columbia, or Washington) is essential and useful. In general, most participants learned a lot, and recognize that much more research is required. It was also clear that DFO, as well as other research and management agencies may tend to overlook the importance of disease as a management concern. Workshop participants recommended that DFO should be mindful of disease issues when considering management actions in general but especially in impoundment fisheries.