Part 3 of 4

Bob Sam
Sitka Tribe

RC 29

In 2017, DFO Canada issued a Science Advisory Report involving the development of limit reference points (LRP) for herring (DFO 2017). According to the report, an LRP should be positioned before a state of serious harm occurs, rather than at the state of serious harm and must be avoided with high probability. Furthermore, serious harm applies not only to the stock of interest, but also to dependent species (e.g., predators) and other ecosystem resources (e.g., habitat). The DFO report concluded, in part:

- Experience with the current harvest strategy since 1986 indicates that persistent low production and low biomass states can occur when target harvest rates are set at or below 20% of the forecasted spawning biomass.

- A spawning biomass-based LRP of $0.3B_0$ rather than $0.25\boldsymbol{B}_0$ is recommended based on results of the production analysis *and* consistency with international best practice recommendations. The phasing-in of any new management procedure (i.e., harvest control rules) designed to avoid LRPs and achieve targets is recommended to mitigate short-term consequences to resource users. This revised threshold value is higher (more protective) than the threshold currently used in Southeast Alaska ($25\%\boldsymbol{B}_0$).

- Ecosystem service requirements of Pacific herring predators were not directly considered in the LRP analysis because information is currently insufficient to identify predator requirements, but the report noted the importance of herring in the ecosystem.

- The decline in herring spawning biomass in BC was preceded by declines in observed weight at age and increasing estimates of natural mortality that began about 1990. The transition to a low production/low biomass state for the Central Coast, HG and WCVI stocks was rapid, occurring in three years (less than one herring generation). The low production/low biomass state persisted for six years to eleven years depending on stock, despite large commercial catch reductions (harvest rate < 20%), or cessation of commercial catches.

ADF&G is aware of these recent findings in BC. For example, Hebert (2017b) stated in a report to the Board of Fisheries, *"recent research in British Columbia (BC) and elsewhere suggests that harvest rates and threshold levels may need to be reevaluated to better avoid states of low biomass and low productivity and to allow populations to recover from such states. In particular, research indicates that harvest rates of 20% may not be effective at allowing stocks in low productivity states to rebuild, and that thresholds in BC should be set high enough so that the probability of the population falling below 30% of pristine biomass is very low."*

"Go with Older Fish" and Size Selective Harvests

As discussed above and documented by Thornton et al. (2010a), STA is concerned that the commercial herring fishery selectively harvests larger, older herring, thereby interfering with the ability of the older herring to guide younger first time spawners back to the previous spawning grounds. This is a important issue because STA subsistence harvests and observations indicate lower quality and quantity of roe along the traditional subsistence grounds, whereas the commercial fishery has typically maintained harvest levels (except in 2013 and 2018). Furthermore, "straying" to less used spawning areas could reduce the productivity if habitat and currents are less favorable.

Observations by STA about the spawning fidelity of herring are consistent with TEK provided by the Haida Nation in BC. According to McCall et al. (2018), Chief Gidansta (Guujaaw) of the Haida Nation, stated that the impact of intense commercial fishing on age structure was associated with loss of migratory knowledge: *"Once herring lost the elders they lost their way to their spawning grounds."*

There is some support for the concept of learned migration among forage fishes in the scientific literature. An ICES Working Group concluded that learned migration is a widespread phenomenon (Petitgas et al. 2006, ICES 2007). Learned migration is evident in populations of North Atlantic herring (*Clupea harengus*). Consistent with TEK, Corten (2002) hypothesized that recruiting year classes of North Atlantic herring learn the migration pattern from older fish and that a change in migration pattern was usually associated with a relatively low ratio of experienced older fish to first-time spawners. Huse et al. (2010) provided evidence for this tendency in Norwegian herring by examining time series of age compositions. Space-time occurrence models of Icelandic herring suggest a *"wisdom of the crowd"* mechanism whereby larger, more effective schools lead to improved navigation to spawning grounds (Macdonald et al. 2017).

In British Columbia, Ware and Tovey (2004) examined disappearance and recolonization events of herring as part of a broad metapopulation. For the period 1943-2002, they identified 82 spawn disappearance events, and found that 55% of the 76 spatial "sections" experienced one or more disappearance events in the last 60 years. Smaller sections experienced greater fluctuations than larger sections. Herring recolonized sections, but only 53% were successful. They reported a high degree of straying between nearby sections. Ware and Tovey (2004) reported that dynamics of the southern BC metapopulation changed in response to the 1977 climate shift.

McCall et al. (2018) explored a "Go with the Older Fish" (GWOF) mechanism of learned migration behavior for exploited fish populations, such as Pacific herring, where recruits learn a viable migration path by randomly joining a school of older fish. Using a simulation modeling approach, the GWOF strategy was compared with a diffusion strategy where recruits adopt spawning sites near their natal site without regard to older fish. McCall et al. (2018) concluded:

- As total mortality increases, the GWOF strategy results in abandonment of less productive sites and maintenance of high biomass at more productive sites.

- Fishing disproportionately affects populations with GWOF behavior.

- There is a tendency toward local site extinction when fishing interacts with the GWOF strategy. Numerous such declines and local disappearances have occurred in the last three decades, necessitating implementation of a minimum stock size threshold in Pacific herring management.

- Under the GWOF strategy, a relaxation of fishing pressure does not lead to immediate recolonization of abandoned sites, and reestablishment at former spawning sites may require decades.

- Sustainable harvest rates for Pacific herring stocks should be evaluated over periods of high and low stock productivity, where the evaluation is stock specific. This is important because estimates of the exploitation rate corresponding to MSY for Pacific herring populations differ among populations and over time.

- The GWOF model indicates that productivity of fished populations may decline over decades due to spatial reorganization of the population.

- Recognize that even with no harvest, individual herring may abandon spawning sites for unknown reasons.

The findings of McCall et al. (2018) highlight the need to further evaluate observations by the Sitka Tribal members and First Nations in BC with regard to the GWOF concept because GWOF has important implications for management of the herring fishery. In particular, the degree of selective fishing for older and larger herring should be evaluated.

Serial Depletion Hypothesis

Hay et al. (2007) examined the hypothesis that that the herring roe fishery has led to systematic reduction in the number of distinct spawning locations in British Columbia. This hypothesis stemmed from the observation that harvest rates on herring in a specific section of a major assessment area may greatly exceed 20% even though the targeted maximum harvest rate (20%) for the large assessment area was achieved. The investigators reported that herring spawn locations are dynamic, as previously described by Ware and Tovey (2004), but that there is no evidence to support the hypothesis of serial depletion during the roe fishery as an explanation for those changes. Nevertheless, the science team recommended that managers spread catches spatially and resist taking the entire catch from the same location. This approach has been incorporated into herring management in BC and the authors concluded that concerns about the loss of genetic diversity appear to be unwarranted.

Herring Contribution to the Marine Ecosystem

Forage fishes are key to marine food web dynamics because they transfer production from zooplankton to larger piscivorous species that feed on forage fishes. Herring provide valuable prey for marine birds, marine mammals such as humpback whales, and piscivorous fishes. For example, DFO Canada estimated the following contributions of adult herring to the diet of key species: Chinook salmon (62%), coho salmon (58%), Pacific cod (42%), and Pacific halibut (53%) (Fig. 20). Reid (1961) and Wing (1985) examined the diet of Chinook and coho salmon captured in the Southeast Alaska troll fishery (1957-1958; 1977-1984). Both studies reported that herring were the dominant prey in both salmon species. Furthermore, larger salmon consumed more herring.

The abundance, size at age, and age at maturation of Chinook salmon in Alaska has declined over time (Lewis et al. 2015, Ohlberger et al. 2018), leading to concerns about the declining status of Chinook salmon and the significant hardship for people in Alaska. A variety of factors have been hypothesized to influence the growth and abundance of Alaskan Chinook salmon. An important question is the extent to which herring in coastal waters may have contributed to the decline of Chinook salmon.

Scheigert et al. (2010) estimated the consumption of herring by 13 key predators off the west coast of Vancouver Island over a 35 year period (1973-2008) and reported that fishes and marine mammals consumed an average of 133,541 tons (60,563 mt) of herring, or approximately 54% of the average spawning-stock biomass of the two herring populations that occurred in this area. Other investigators cited by Scheigert et al. (2010) reported that three fishes (hake, sablefish, Pacific cod) consumed 29-54% of the adult herring stock in this area. Consumption of herring declined over the 35 year period, largely in response to declining abundances of key predators. Peak annual consumption of herring was nearly 200,000 tons (90,000 mt). These studies did not provide values for many other predators, such as salmon and birds (Chinook abundance is low and they have a small effect on herring abundance even though herring are very important to Chinook salmon in coastal areas). Scheigert et al. (2010) concluded that herring *"population recovery is expected to be facilitated by a combination of factors, including adequate food supply, limited or reduced predation (including fishing), and limited competition particularly for wasp–waist systems, where different forage species may occupy similar niches."*

According to Carlile (1998), the original goal of the threshold/variable harvest rate policy was to maintain herring populations above the threshold escapement levels. These levels and the variable harvest rate schedule were *"intended to protect herring stocks from sharp reductions due to recruitment failure, to maintain adequate abundance of herring as prey for commercially important predator species such as salmon, and to provide for the quality commercial herring products."* The goal of maintaining adequate abundances of herring as prey for commercially important species, such as Chinook salmon, is a key assumption that has not been fully addressed. In his report to the Board of Fisheries, Herbert (2017b) acknowledges the importance of forage fishes to other species in the ocean and notes that some scientists conclude that minimum biomass thresholds for fishing should be at least 40% of pristine biomass to maintain adequate forage for other species.

An annual 20% harvest rate might seem somewhat small or conservative but this annual rate ultimately removes a much higher fraction of each herring cohort from the ocean and from predators that depend on herring for food. The cumulative percentage of a herring cohort that is removed by a fishery depends on the annual harvest rate and natural mortality rate. If the annual harvest rate is constant at 20% for age-3 and older herring, then the fraction of the age-3 and older herring removed by the fishery increases from approximately 33% to 38% to 45% as the assumed annual natural mortality rate decreases from 50% to 40% to 30%, respectively. This simple analysis does not consider the additional effect of extracting 20% of the herring eggs from the spawning grounds each year in terms of the food provided by the eggs to predators and to future herring production. The cumulative impact of an annual 20% harvest rate on a forage species population is more than it might seem.

Recommendations

- Re-evaluate the commercial harvest threshold for Sitka Sound herring using all available data, including approximations from the early fisheries when total biomass appeared to be very high and the more recent total biomass values that extend well beyond the values used by Carlile (1998). Also, consider the recent finding by DFO (2017) in British Columbia (BC) to increase the threshold from 25% to 30% of the unfished biomass, as a means to further protect herring populations at low abundances while also supporting predators that depend on herring for food. This analysis should avoid the problem of a shifting baseline that might reflect climate shifts and fishery harvests, as discussed by DFO (2017). In other words, a threshold based on an unfished biomass estimated from biomass data in the 1970s and 1980s would lead to a low threshold and allow harvests to begin at a low population size compared with an analysis that included other time periods when biomass was high. The analysis to establish a harvest threshold should also consider the "Go with Older Fish" (GWOF) or learned migration strategy, given TEK observations in Southeast Alaska and BC, scientific findings by the ICES scientists, and the implications for harvest management as described by McCall et al. (2018). Additional investigation into learned migration of herring is needed.

- Consider a harvest threshold based on a minimum spawning biomass rather than minimum total biomass. For example, in BC a harvest is not allowed until the estimated spawning biomass reaches a minimum level <u>after</u> projecting a 20% harvest rate on the herring run. As noted above, the BC harvest threshold has been recently increased from 25% to 30% of the estimated unfished biomass, as a means to protect the herring population from overfishing at low populations levels. Current management in BC is more protective of herring at lower herring abundances than in Southeast Alaska, but fisheries in BC reach the 20% maximum harvest rate quicker after the minimum threshold is reached.

- Manage the Sitka Sound commercial herring fishery using the same harvest rate schedule as in other herring fisheries in Southeast Alaska. In Sitka Sound, a much more aggressive harvest rate is used once the harvest threshold has been reached. In Sitka Sound, the initial harvest rate is 12% rather than 10% as in all other regions, and the maximum 20% harvest rate is reached at 1.8 times rather than 6 times the threshold level. The biological basis for the higher harvest rate of the Sitka Sound fishery is not apparent. Furthermore, the decline in biomass of herring in Sitka Sound is coincident with the more aggressive harvest rate schedule.

- Consider the importance of abundant herring for supporting numerous commercially and socially important species, including Chinook and coho salmon, Pacific cod, and other species that have recently declined. ADF&G biologists recognized the ecosystem benefits of herring, but they simply assume the current management approach sufficiently protects this benefit. To this extent, DFO (2017) should be consulted since this team of scientists identified the need to raise the threshold to 30% of the unfished biomass. DFO (2017) identified the need to further quantify the needs of marine species for abundant herring; their revised threshold did not consider ecosystem benefits but it did recognize the need to do so.

- Expand the current closed commercial fishing area that is intended to reduce interactions with subsistence fishers, whom have a priority in Alaska. Recent commercial fisheries often harvest herring immediately adjacent to the closed area boundary and these harvests and activities likely reduces the availability of herring roe to subsistence fishers. The extent of the closed fishing area will become more important if the Sitka Sound herring population continues its downward decline, which began about 10 years ago. Other herring stocks in Southeast Alaska and BC have been declining over time and many populations no longer support fisheries, indicating the need for a more precautionary approach to herring management. In Sitka Sound, subsistence needs are not typically met.

- Monitor spawn density, which is a key factor affecting subsistence users. Evaluate discrepancies between Age Structured Assessment (ASA) biomass estimates and those based on field surveys. The primary discrepancy appears to occur when field surveys estimate a large herring biomass. Biomass estimates (forecast and observed) should include confidence intervals that reflect the degree of uncertainty in the values. The preseason forecasted age composition should be compared with the observed age composition as a means to track year class strength over time.

- Quantify the degree of size and age selectivity by the commercial seine fishery in Sitka Sound in response to their targeting of larger, older herring. Consider this information in management analyses and decisions while considering the implications of the "Go with Older Fish" on herring management, as described by McCall et al. (2018).

- Estimate the degree of premature (false) spawning associated with the herring test fishery and commercial fishery, and the degree to which commercial fishing activities cause herring to spawn in less favorable habitat.

- Anticipate low herring runs that might result from climate change and poor ocean conditions. In most years, ADF&G has managed the commercial fishery to be close to the pre-season guideline harvest level. In 2018, herring body size was too small for the market, and the fishery was stopped early. Managers should examine herring abundance inseason to ensure biomass is sufficient to allow a commercial harvest. A cautionary approach is especially important during a period of declining abundance, such as shown by herring throughout Southeast Alaska in recent years.

- Incorporate factors, such as oceanographic events (climate change), or other approaches (i.e., time series), into forecasting methods and models in an attempt to anticipate a downward trend in herring biomass as shown in recent years. This would help reduce the likelihood of commercial harvests exceeding the harvest guideline level. Guideline harvest levels should consider the forecasted age composition of herring and the degree to which the commercial fishery harvests larger and older herring. The commercial fishing industry desires old, large herring that have greater roe content, but these fish are also more important to the sustainability of the herring population.

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