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SIZE AT 50% MATURITY FOR SOUTHERN GULF OF ST. LAWRENCE HERRING (NAFO 4T)

Context

By regulation and variation order, the current minimal landing size for Atlantic herring in the southern Gulf of St. Lawrence (sGSL) is 24.5 cm (fork length). While the minimum size was originally put in place for market reasons, a science review in 1995 concluded that with the 24.5 cm fork length regulation, purse seiners were catching a very small proportion of immature herring, approximately 2% in 1994 and 5% in 1995 (Claytor et al, 1996). In the regulations, a 10% catch of herring less than 24.5 cm is allowed and other management measures are taken when this level is exceeded. In the 2007 herring seiner fishery, a higher proportion of herring less than 24.5 cm was being caught compared to previous years. Advice was requested by Fisheries and Aquaculture Management to determine the current size at 50% maturity for the sGSL herring stocks.

Background

The herring population in the sGSL consists of two components, a spring spawner component and a fall spawner component, harvested by an inshore fixed gear gillnet fleet (77% of the quota) and a mobile gear purse seine fleet (23% of the quota), both fishing in the Northwest Atlantic Fisheries Organization (NAFO) area 4T. A large proportion of the purse seine fleet landings occurs in September and October.

From biological samples, maturity is determined by laboratory examination of the gonads checked against a gonado-somatic index range. Spawning group assignment of non-spawning mature herring is done with a gonado-somatic index to assign maturity stage and a monthly key that links maturity stage and month to spawning group. For juvenile immature herring, spawning group assignment is done by size at capture and otolith shape.

To obtain the full range of sizes of both immature and mature herring from biological samples, research surveys were used as the data source for maturity analyses. The annual herring acoustic survey conducted in early fall (late September-October) collects fish samples from concentrations of herring in the inshore areas of Chaleur-Miscou, and north of Prince Edward Island (P.E.I.) (LeBlanc et al, 2007). The annual September groundfish bottom trawl survey samples herring throughout the sGSL in slightly deeper inshore waters. (Hurlbut et al, 2007). The two surveys cover the main fall concentrations of both spawning components and occur concurrently with the peak of the fall fishery.

Analysis and responses

Methods

Two maturity classes were created from the gonad maturity data of individual fish of both spawning components from the detailed samples: 1) *Immature:* juvenile or immature herring 2) *Mature*: all pre-spawning, spawning and post-spawning mature herring. All fish from the detailed samples were measured to total length. The regulatory minimum length is in fork length. For the purpose of this analysis, all total lengths were converted to fork length using a conversion established from 2004 laboratory measurements. The equation used was: Fork length = (0.8973 * total length) + 0.032. A fork length of 24.5 cm corresponds to 27.3 cm total length.

The median fork length at maturity (L_{50}) is defined as the length at which 50% of individuals are mature and is generally used to describe the sexual maturity of fish stocks. Acoustic and groundfish survey herring data from the years 1995 to 2006 were examined.

	Acoustic Survey			Groundfish Survey		
	Fall spawners	Spring spawners	samples	Fall spawners	Spring spawners	samples
Year	sampled	sampled	n	sampled	sampled	n
1995	209	435	13	645	321	22
1996	420	469	16	326	228	16
1997	559	334	17	917	401	26
1998	1422	1462	52	856	213	17
1999	694	449	22	440	190	23
2000	1085	358	26	453	145	16
2001	901	1035	35	524	152	21
2002	480	451	16	408	233	19
2003	454	473	18	243	62	11
2004	372	331	14	594	216	23
2005	2112	550	51	471	172	18
2006	984	310	26	345	94	13

Analyses were conducted on the data from each survey and year, for both spawning components separate and then combined. L_{50} was estimated from the observed proportion of mature fish at each length using a logistic model (SAS PROC PROBIT). The analyses were first conducted using the observed unweighted proportion of mature fish in the biological sampling, then using the same proportion weighted by an index of abundance at the sampling location. Sampling from the acoustic survey was restricted to Chaleur Bay and the northern shore of P.E.I. where both herring and the fishery are concentrated at that time of the year. Sampling from the groundfish survey used all sampling locations.

Differences in maturity between male and female herring were examined by estimating L_{50} with confidence intervals for five years with a high number of samples. To assess the effect of geographic differences in L_{50}, the acoustic survey data from years with a high number of samples were divided into two sectors; Chaleur Bay (NAFO areas 4TM and 4TN) and north of P.E.I.

Inter-annual differences in L_{50} were tested by comparing the Chi-squared statistic associated with the year effect against 1000 analyses conducted with the data randomly assigned to year. Models fitted using weighted observations provided less variable estimates of annual L_{50}; however, the confidence limits of L_{50} were sensitive to the scale of the weighting factor and considered unreliable. We calculated the confidence limits of annual L_{50} by sampling the data with replacement within each year (bootstrap method). The 95% confidence limits from the bootstrap analyses were derived from the 2.5 and 97.5 percentiles of the 1000 estimates of L_{50} for each year.

Results

L_{50} was compared between male and female fall-spawning herring in acoustic surveys of Chaleur-Miscou over five years. In all years examined, L_{50} was not significantly different between sexes. All further analyses were made combining male and female herring.

In the acoustic survey, herring tended to be concentrated in Chaleur Bay and 75% or more of the samples came from the Chaleur-Miscou area. However, in 2000, 2005 and 2006 there was sufficient sampling from P.E.I. to permit an analysis comparing Chaleur-Miscou with the area north of P.E.I. L_{50} was significantly greater in the Chaleur-Miscou area than north of P.E.I. in 2000 and 2005, but similar in 2006. In all cases, the L_{50} at maturity was lower in the P.E.I. area and it was concluded that the use of data from both areas would be more appropriate to better cover the stock area.

The randomization test to verify inter-annual variations in L_{50} was highly significant, thus the data were analysed by year. After considering both spawning groups separately, it was concluded that the differences in L_{50} by year were not significant for most years of the time series and the data was combined. It was also considered that combining the data better reflects the species composition of the fall seiner fishery catch. Examples of the logistic model maturity ogives are presented for a combination of years (1999-2006) of data for both surveys (Figure 1).

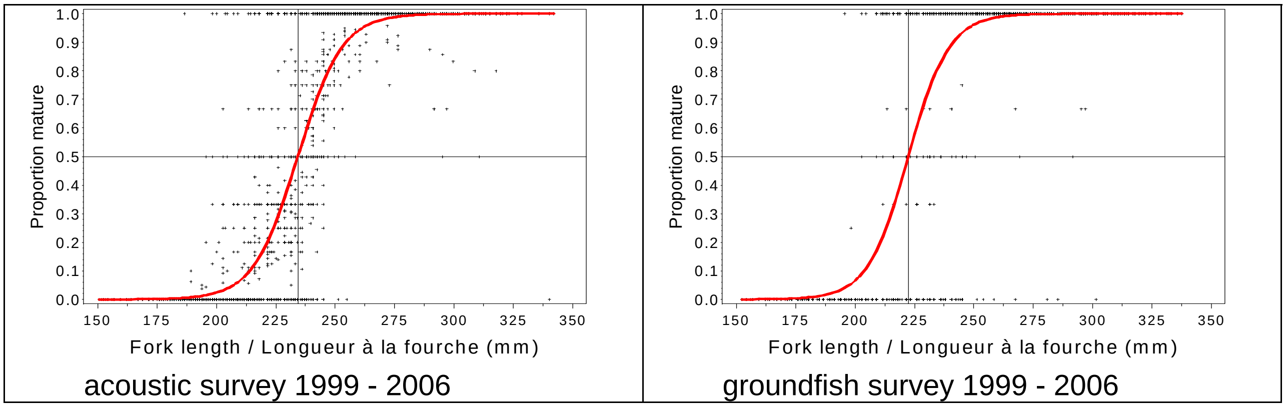

Figure 1. Maturity ogives of 4T herring for selected years by survey.

The estimated fork lengths at 50% maturity from the groundfish survey data were generally lower than the acoustic survey estimates. The same results were noted when comparing the L_{50} from the two areas of the acoustic survey. It was concluded that the groundfish survey undersamples the Chaleur area with fewer sets and that fishing sets are generally in deeper waters than the depth in which herring are found at that time of year. The number of samples in the L_{50} range in the groundfish survey data was also lower than in the acoustic survey data.

To determine the L_{50} values, the models were fitted to the weighted acoustic survey biological data. The confidence limits of L_{50} on the weighted observations were obtained by bootstrap simulations (Figure 2). When averaged over the approximate number of years that a herring currently can spawn (eight years), the fork length at maturity (L_{50}) for the years 1999-2006 is estimated at 23.5 cm.

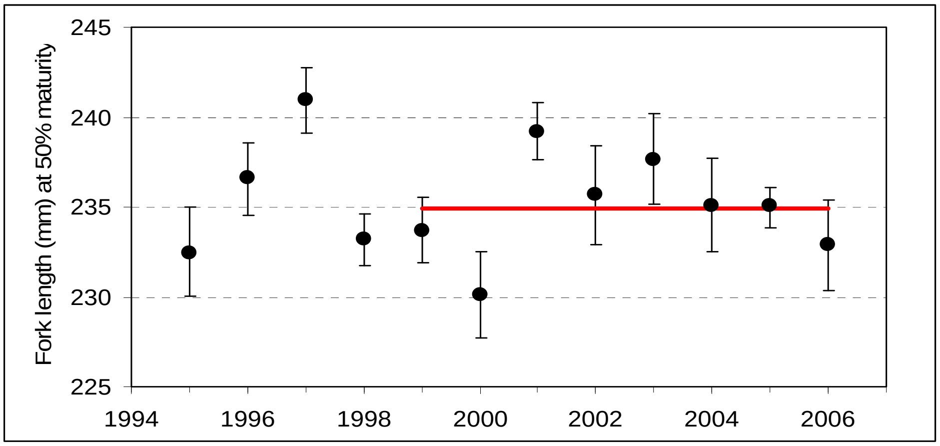

Figure 2. 4T herring fork length at 50% maturity (L_{50}) based on annual acoustic surveys in Chaleur-Miscou and north of Prince Edward Island. L_{50} ± *2.5 and 97.5 percentile confidence limits based on bootstrap estimations on weighted observations. Line represents 1999-2006 average.*

Conclusions

Based on recent acoustic survey biological data averaged over the number of years that a herring can spawn, the fork length at 50% maturity (L_{50}) is estimated at 23.5 cm for sGSL herring.

By using the acoustic survey data, the main fall concentrations of herring were sampled during fall feeding and their migration from west to east of the sGSL. By weighting the data to local abundance, emphasis is placed on the main distribution of herring at the same time of year as the peak fall fishery activities occur, ensuring that the average L_{50} estimate reflects the regional differences that were noted.

Changes in the exploitation profile of a fish stock to include a greater proportion of smaller fish could entail changes in the reference exploitation rate of the stock. Fishing has the potential to alter the evolution of phenotypic traits of fish, including the age or size of maturity (Law, 2000). Depending on the nature and intensity of the fishery, fish stocks may respond with L_{50} declining over time. If one of the objectives of the fishery is to maintain large herring in the stock, a management strategy is required that ensures that herring survive to grow and spawn to a large size.

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Sources of information

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