

Update to the Brenden et al. (2012) Statistical Catch-at-age Assessment for Chinook salmon in the Main
Basin of Lake Huron

QFC Technical Report T2015-01

Prepared by

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Introduction

The purpose of this report is to document revisions to the statistical catch-at-age assessment for Chinook salmon in the main basin of Lake Huron. This revised assessment has been used to assess prey consumption and as a basis for interpreting effects of predators (He et al. 2015). This report does not fully document the model but only the changes in the assessment. Readers are referred to Brenden et al. (2012) for additional details.

Changes to the model and assessment

1. The data were updated to include information through 2012. Where possible new inputs were obtained from original sources for prior years. This led to some changes in data from earlier years, likely reflecting corrections in the source data, but generally the changes were small. The one major change to the input data was the effort data. Brenden et al. reported that they used effort from salmon and trout index ports but actually used total fishing effort. This error was corrected so the assessment now uses the index port effort data. In addition, sensitivity analysis showed that the use of different effort series had little impact on the results from the original assessment of Brenden et al. (2012) in terms of population status, dynamics, and mortality, because the model allowed for time-varying catchability. As a further sensitivity analysis the model was also fit using total "salmon and trout" effort estimated based on angler reported targets for the entire Michigan non-charter fishery, and this series also produced similar results for population size and sources of mortality as the original assessment model. All data used as inputs to the assessment are given in an Appendix to this report containing the "dat file" read in when the assessment is fit.

2. The Swan Creek weir returns were down-weighted to the point that they had essentially no influence on assessment results. Concerns had been raised that the weir returns may not be reflective of lake wide changes. Earlier sensitivity analysis had suggested that the results were not sensitive to weighting but after the model was revised the results became sensitive to the use of the weir data but only if the weight on the weir data was set very low.

3. The percentage wild assumed for the 1987-1993 year classes was increased from 15% to 45%. The 15% figure had been based on the percentage wild of young fish in shore seine sampling in Michigan and this underestimated total contribution given that sampling was before complete dispersal and near stocking but not wild production sources. Assessment results were surprisingly insensitive to this input, likely because the total abundance of fish was well estimated so any change in wild fish was compensated for by an offsetting change in age-0 mortality.

4. A major change to the assessment model was to modify the model for catchability. Several biologists within the Michigan DNR and OMNR had questioned the magnitude of changes in catchability and had argued that the large estimated changes were not plausible. In particular concerns were expressed that the overall level of fishing mortality was unreasonably high in recent years and that the number of spawners that was surviving was probably not sufficient to explain the strong runs still seen in Ontario streams. Our changes moved away from a random walk approach to modeling catchability given other experiences that suggested that this can be problematic in an assessment with other time varying processes modelled by random walks (as in this model where age-0 natural mortality was influential and varied according to a random walk). Instead we developed a more mechanistic approach to modeling time-varying catchability, while still allowing some stochasticity.

In particular, the recreational fishery catchability prior to 1986 (q) is constant and estimated as a fixed parameter as in Brenden et al. 2012. Starting in 1986 the recreational fishery catchability is modeled as the product of q (catchability prior to 1986), an increase in catchability for the time block 1986 and later versus earlier years (τ) reflecting evolution of the fishery, a power function of the inverse of weight at

700 mm normalized to 1986 (so no effect for 1986 and catchability increases as weight at 700 mm decreases), a year-specific "area adjustment" and year specific deviations (ε assumed to be normally distributed on a log scale - i.e., white noise):

$$q_y = q\tau \left[\frac{W_{700,1986}}{W_{700,y}} \right]^Y Adj_y \exp(\varepsilon_y) \quad \varepsilon \sim N(0, \sigma_\varepsilon^2) \quad (1)$$

The area adjustment (Adj) was the proportion of total salmon and trout effort in Michigan's waters of the main basin that occurred in MH1 and MH2, normalized to 1986. Thus as the fishery became more concentrated in the northern part of the lake (as occurred later in the time series) catchability tended to increase over that seen in 1986. The conceptual model here is that the concentration of effort spatially reflects an overall concentration of fish to a smaller area, making them more catchable.

The inverse of weight at 700 mm is used as a surrogate for hunger, with thinner fish being viewed as being hungrier and more likely to strike lures. The idea with allow catchability to jump in 1986 is that this reflects a more efficient fishery than the early period and in addition starting in 1986 there is actual effort data rather than an assumed pattern.

Both weight at 700 mm and the area adjustment factor showed substantial changes over time (Figures 1 and 2) with weight being lower and the area adjustment higher in later years.

5. Some changes in the treatment of natural mortality were implemented. For age-0, natural mortality from 1982 through the next to last year with data (now 2011) followed the random walk, as described by Brenden et al. (2012) with age-0 natural mortality in the last year set equal to that in the next to last year. For years prior to 1982, however, we used a different approach, setting all values equal to the same value estimated for 1982. This contrasts with the treatment of Brenden et al. (2012) who set the natural mortality equal to 0.7 in 1968, with a linear increase until 1980, at which it remained constant through the estimated value for 1982. We had little confidence in the prior estimate of 0.7 or the timing of any change in natural mortality prior to 1982. However, this change had negligible impact on results. A more substantive change was we also allowed for time varying natural mortality of age-1 and older. The model used the same assumed age-specific values from the first year through 1986 but starting in 1986 these values were multiplied by $\left[\frac{W_{700,1986}}{W_{700,y}} \right]^b$ starting in 1987 (b estimated). This allows M to change over time inversely with changes in weight at 700 mm after 1986. This change made a substantive difference in that it allowed for higher adult mortality when condition was low. Previously some modest evidence for relatively fewer older fish in later years had been interpreted by the model as evidence for high fishing rates as this was the only way the model could achieve higher mortality. The higher mortality when condition was low made sense given these fish were clearly in an unhealthy state when condition was at its lowest.

6. The objective function used to measure model fit, for which parameters were adjusted to minimize, remained structurally unchanged, but "weights" on data sources were changed. For the objective function component related to catchability deviations the equation analogous to equation T2.3 is now:

$$L_\varepsilon = n_\varepsilon \log_\varepsilon \frac{\sigma}{\sqrt{\lambda}} + 0.5 \frac{\lambda_\varepsilon}{\sigma} \sum_y \varepsilon_y^2 \quad (2)$$

Note that the white noise deviations (ε) were defined on a log scale (with $\exp(\varepsilon)$ being multiplicative errors of equation 1) so that their squares are summed rather than summing the square of their logs. This is identical to how the random walk deviations were specified by Brenden et al. (2012). They correctly coded the objective function using components of the form given in eq. 2, but incorrectly indicated in their Table 2 that sum was for squared log transformed deviations.

While the structure of the objective function was unchanged the weighting factors did change. Like Brenden et al. (2012) each component of the objective function was effectively weighted by the variance (for normal components) or the effective sample size (multinomial components). For the normal components the variances equal $\frac{\lambda_i}{\sigma}$ where i indicates the type of deviation. The weights for the normal components other than the recreational fishery (set to 1 as a standard) and the Swan Creek weir return data (down weighted to 0.001 as described above) were altered iteratively so that the rough match described by Brenden et al. (2012) was achieved for catch residuals. The resulting values for λ were {1, 0.001, 0.5, 1} for the recreational harvest, the Swan Creek returns, the random walk for age-0 natural mortality, and the white noise catchability deviations. Effective sample sizes were fixed at the observed sample size up to a maximum of 50 as described by Brenden et al. (2012).

Results and Discussion

The purpose of this report was not to present a detailed evaluation of the stock status for this updated model, but instead to document changes made to the model. Nevertheless it is worth commenting on a few aspects of the resulting model fit. First the basic diagnostics (residuals, retrospective patterns, MCMC chain properties) all suggested a technically reasonable fit. Second the overall general pattern of decline in Chinook salmon late in the time series, driven largely by a decline in age-0 survival that was reported by Brenden et al. (2012) is retained (Figure 3). The previous model had indicated that as this decline occurred abundance became so low that fishing became excessively high. The current model estimates a much less severe increase in fishing mortality and less of an increase in catchability (on the order of 7 fold rather than the 50 fold of Brenden et al. 2012), accompanied by a modest increase in natural mortality during a period corresponding with higher fishing mortality (Figure 4). We believe these results are more plausible and suggest that fishing did not reach levels of serious concern as the previous assessment was suggesting. In large picture both versions of the assessment gave a similar picture of a decline in Chinook salmon abundance driven by age-0 but they do give substantially different pictures of the intensity of fishing and the revised model suggests a less extreme decline with a somewhat different timing.

- Brenden, T. O., J. R. Bence, and E. B. Szalai. 2012. An age-structured integrated assessment of Chinook Salmon population dynamics in Lake Huron's Main Basin since 1968. *Transactions of the American Fisheries Society* 141: 919-933.
- He, J. X., J. R. Bence, C. P. Madenjian, S. A. Pothoven, N. E. Dobiesz, D. G. Fielder, J. E. Johnson, M. P. Ebener, A. R. Cottrill, L. C. Mohr, and S. Koproski. 2015. Coupling age-structured stock assessment and fish bioenergetics models: a system of time-varying models for quantifying piscivory patterns during the rapid trophic shift in the main basin of Lake Huron. *Canadian Journal of Fisheries and Aquatic Sciences* 72:7-23
- He, J. X., J. R. Bence, J. E., Johnson, D. Clapp, and M. P. Ebener. 2008. Modeling variation in mass-length relations and condition indices of lake trout and Chinook salmon in Lake Huron: a hierarchical Bayesian approach. *Transactions of the American Fisheries Society* 137:801-817.

Figure 1. Pattern of changes in weight at 700 mm over time. Weight at this length was generated from weight-length models similar to those described in He et al. (2008) .

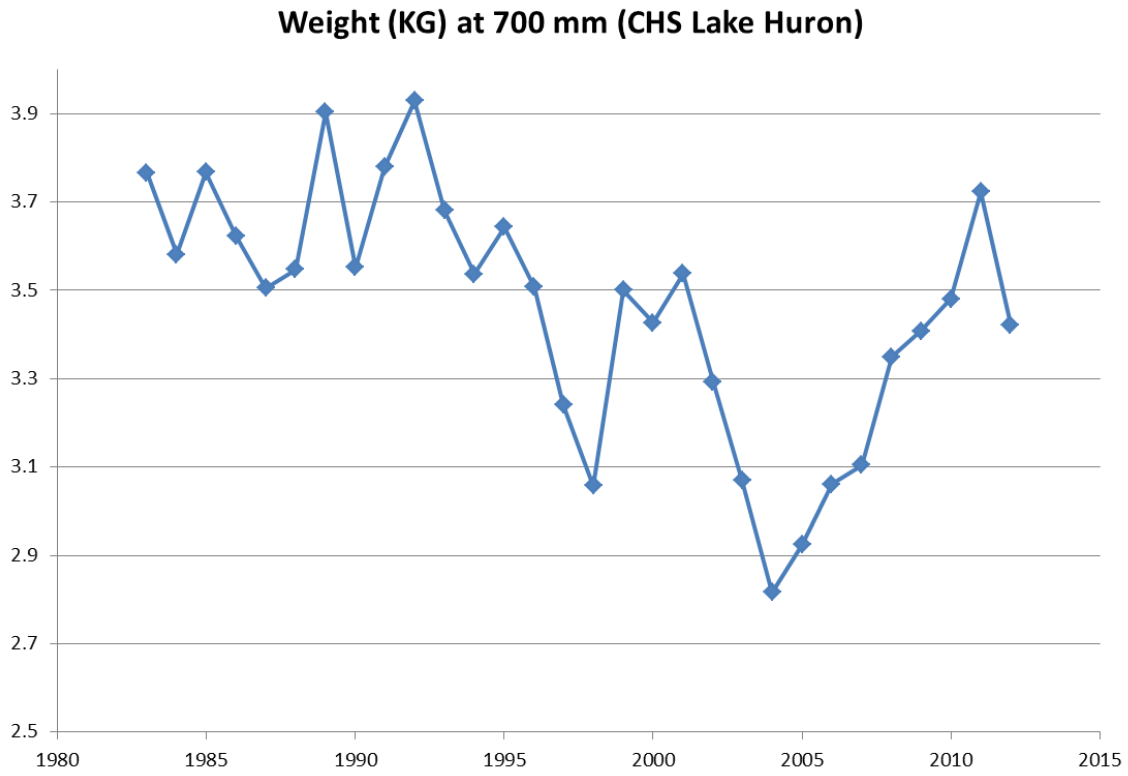


Figure 2.

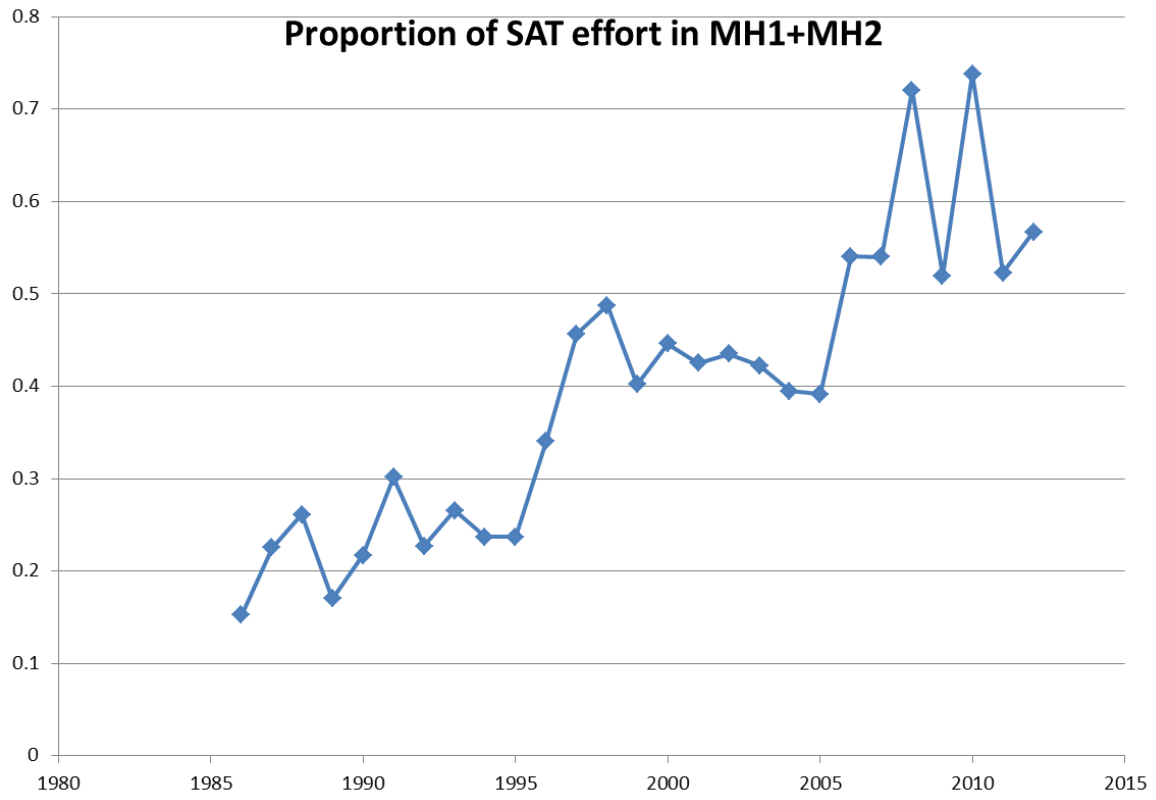


Figure 3. Estimates of biomass and age-0 natural mortality from the revised Chinook salmon model for the Lake Huron main basin.

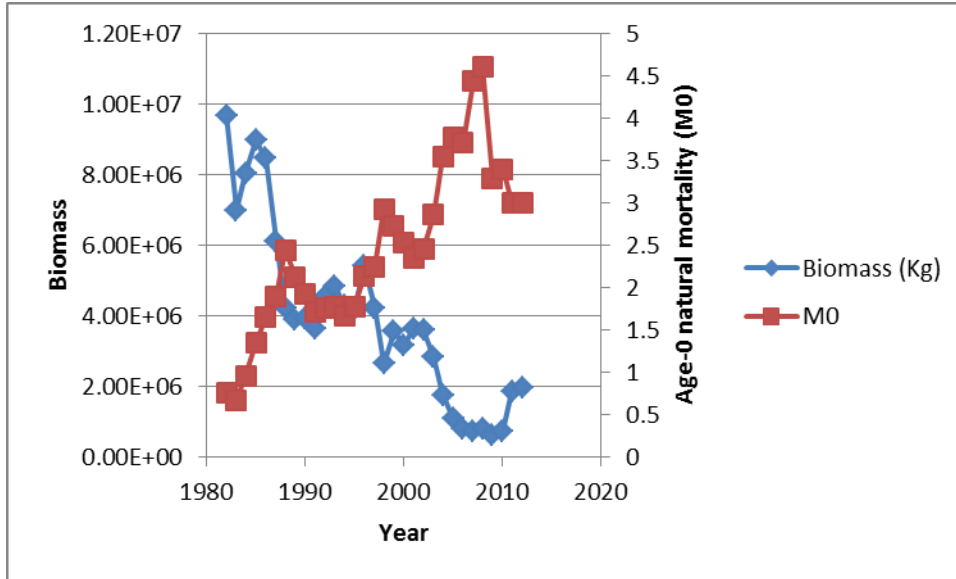
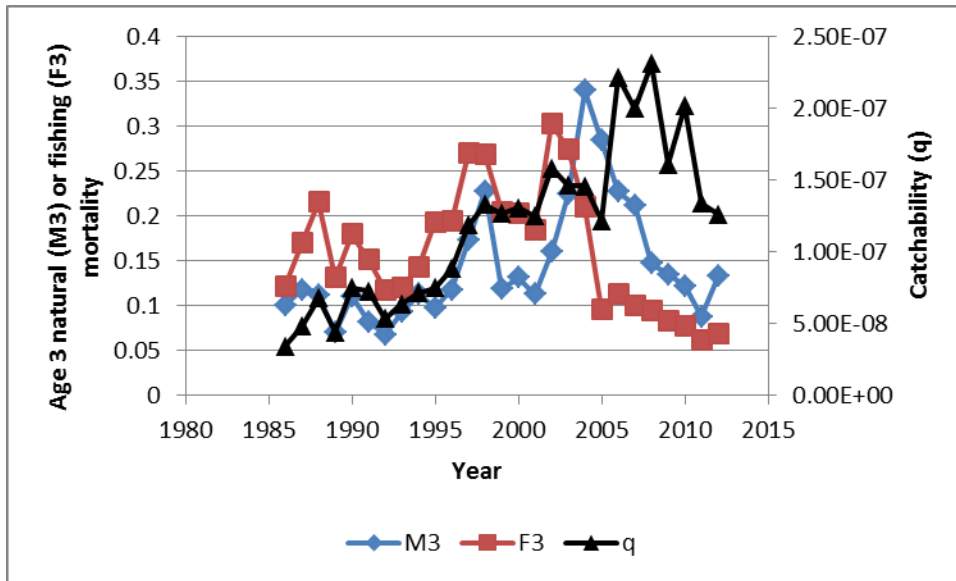


Figure 4. Estimates of annual instantaneous fishing mortality at age-3 (averaged over months give the seasonal pattern) and natural mortality at age-3 along with annual catchability for the recreational fishery.



Appendix to T2015-01. Data file used for updated assessment model

#First and last area adjustment years
1987 2012

#area adjustments for catchability
#These are calculated from SAT effort
#Inverse proportion of effort in MH1+MH2
#Normalized to proportion in 1986 [p(86)/p(y)]
Note is code q adjusted by dividing. Same as multiply non-inverse
0.6763 0.5836 0.8942
0.7022 0.5048 0.6710 0.5734 0.6431 0.6431 0.4469 0.3337 0.3124 0.3790
0.3414 0.3582 0.3500 0.3604 0.3859 0.3891 0.2819 0.2820 0.2113 0.2932
0.2063 0.2912 0.2685

#FIRST AND LAST WL COEFF YEARS
1983 2012

alpha beta N
9.609E-09 3.0204 181
5.107E-09 3.1092 122
1.1383E-08 2.9946 244
1.0399E-08 3.0024 530
9.378E-09 3.0131 499
4.674E-09 3.1212 288
4.195E-09 3.1524 108
3.022E-09 3.188 54
5.27E-09 3.1125 147
8.813E-09 3.04 202
3.093E-09 3.1899 279
1.955E-09 3.2539 137
7.076E-09 3.062 194
1.414E-09 3.302 253
2.795E-09 3.1859 327
2.304E-09 3.2066 314
2.515E-09 3.2138 224
3.705E-09 3.1514 398
4.77E-09 3.1177 416
3.64E-09 3.148 396
9.8E-10 3.3376 371
2.823E-09 3.163 394
1.492E-09 3.266 173
2.505E-09 3.194 232
4.175E-09 3.1181 155
2.235E-09 3.2251 139
4.745E-09 3.1128 99
6.488E-09 3.0683 133
3.931E-09 3.1551 105
6.083E-09 3.0755 188

REF length for WL
700

#FIRST and LAST MODEL AGE
0 5

FIRST MODEL YEAR LAST MODEL YEAR (FOR RECRUITMENT)
1968 2012

input nat mortality at age FOR CHS (EXCLUDES MATURATION)
0.7 0.30 0.10 0.10 0.10 0.10

Month OF YEAR FOR SPAWNING (1 To 12) Occurs at the end of the month
9

STOCKING AND RECRUITMENT INFORMATION FOR LAKE HURON MAIN BASIN CHS
Numbers used in 2009 assessment retained through 1978
Numbers after 1978 based on current stocking database provided by
Tracy Kolb early April 2013

Numbers fingerlings stocked in LH main basin Michigan waters 1968-2012
273950 250000
643144 894000 484572 967330 776294 655484 830536 643366 1317578 1325033
1877653 1647651 2000787 2695800 3146997 2806300 3185077 3164689 3520429 4200177
3834970 3221778 3047151 3287234 3572559 3829157 3471523 3287581 3311052 2873305
3050366 3024220 2882637 2893200 2901282 2898017 1474393 1406275 1474833 1473620
1468131 1391427 657899

STOCKING IN ONTARIO WATERS OF MAIN BASIN 1968-2012
Data for 1985 on provided by Adam Cottrill March 2013
Numbers are fingerlings plus any yearlings stocked the next year
Number of yearling small (6200 max, zero most years)
0 0
0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 59073 45930 273596 451999 432261
462896 328543 488527 584464 433294 494710 438500 431663 377441 499155
153118 347843 264300 297778 258511 129479 83846 130954 220930 53667
67451 144524 151398

#ASSUMED PROPORTION WILD FOR 87-93 YEAR CLASSES
#MICHIGAN RUNS OF MAIN BASIN
0.45

#ONTARIO RUNS OF MAIN BASIN
0.45

#ASSUMED PROPORTION WILD FOR THE 2000-2003 YEAR CLASSES. DATA FROM J. JOHNSON.

0.782
0.809
0.838
0.811

#Weight at age in creel survey in August.

Estimates for 1983-2012 are averages calculated from MDNR creel biodata
Estimates for 1973-1982 based on growth model fit to bio data from
combination of creel and weir data by Ji He (See Brenden et al. 2012).
3 values for age-4 replaced by model-based values [2004, 09, 11]
Model based values were used when N=1 or 2 and were model number
adjusted by ratio of ave W@age 4 from creel to model averaged
over years 1983-2012
So data are same for 2009 earlier as previous assessment except for
two numbers.

1.85	5.22	8.26	10.41
1.90	5.64	8.92	11.24
1.79	5.17	8.63	11.05
1.73	5.14	8.43	11.08
1.65	4.96	8.35	10.94
1.75	4.93	8.11	10.64
1.63	5.05	8.54	11.40
1.73	4.67	7.55	9.76
1.90	5.32	8.21	10.46
1.61	5.97	9.76	12.40
1.32	2.74	7.79	8.50
1.27	4.20	6.40	8.22
1.31	3.90	6.90	8.02
1.45	4.17	6.16	7.19
1.87	3.40	6.24	7.22
1.28	3.52	6.76	8.08
1.69	3.40	7.90	9.38
2.23	5.01	6.62	8.96
1.40	4.02	7.69	8.85
1.56	3.95	7.15	9.25
1.13	3.86	7.51	10.31
0.81	3.53	7.33	8.56
1.04	3.33	6.82	8.55
1.01	3.87	7.78	8.88
1.05	2.75	5.80	7.51
0.93	2.15	4.39	5.79
1.83	3.70	6.13	7.19
1.02	3.89	6.67	7.22
1.24	3.71	6.62	8.37
1.14	3.33	6.19	9.36
1.05	2.48	5.34	8.83

1.05	2.33	3.83	5.90
1.05	2.46	3.60	5.75
0.98	3.04	4.55	4.24
1.04	3.10	4.80	5.10
1.68	3.61	4.99	6.81
1.40	3.32	5.58	7.17
1.10	3.29	5.47	6.19
1.86	4.67	6.67	7.06
1.21	3.65	5.67	7.47

#Proportion mature by age and year in creel survey in July and August

#1983-2012

#1983-1987 from original dat file. 1988-2012 calculated from growth model april 2013

0.159	1.000	1.000	0.979
0.000	0.474	0.892	1.000
0.159	0.474	1.000	0.979
0.159	1.000	1.000	0.979
0.159	0.258	1.000	1.000
0.073	0.122	0.630	0.919
0.000	0.121	0.873	1.000
0.000	0.250	0.880	0.938
0.700	1.000	1.000	1.000
0.000	0.769	1.000	1.000
0.000	0.276	0.923	0.955
0.000	0.277	0.927	1.000
0.350	0.410	0.962	0.974
0.301	0.597	0.700	0.929
0.000	0.123	0.845	1.000
0.038	0.229	0.759	0.976
0.385	0.442	0.911	0.948
0.000	0.159	0.942	1.000
0.103	0.582	0.910	1.000
0.186	0.668	0.907	1.000
0.250	0.356	0.790	1.000
0.121	0.359	0.714	1.000
0.000	0.404	0.712	1.000
0.158	0.695	0.918	1.000
0.200	0.631	0.948	0.944
0.571	0.611	0.921	1.000
0.222	0.493	0.984	0.857
0.206	0.538	0.903	1.000
0.385	0.833	1.000	1.000
0.109	0.451	0.973	1.000

#Numbers for determining proportion mature by age

#1983-20012

Ages 1-4

#1983-1987 from original dat file. 1988-2012 calculated from growth model april 2013

1	1	4	1
2	1	1	1
1	1	1	1
1	6	8	1
1	31	58	114
41	41	27	74
11	33	55	58
5	16	25	16
10	26	18	14
7	13	12	3
10	29	39	22
14	47	41	9
80	134	157	38
153	139	140	14
20	219	168	35
26	83	137	42
13	104	168	77
42	82	104	22
29	134	166	88
86	184	215	16
8	239	248	9
33	220	220	1
6	94	111	15
19	118	158	68
20	84	77	18
7	108	76	5
9	73	64	7
68	39	31	7
13	84	24	1
64	102	74	9

HARVEST AND EFFORT

Index of directed recreational effort 1986-2012, Michigan waters of Lake Huron

Creel and charter combined angling hours for 10 coldwater ports

89 and 90 filled in based on tot lakewide effort and ratio of index ports to tot during 1986-1994

2118254	2100206	1885919	1683539.474		
1369016.736	1174813	1243522	1133719	1198118	1444349
	1258756	1318273	1108332	956047	
922006	877321	1138103	1112301	851856	465620
226765.6247	272228	320405.56		302807.8578	299053
				241476	304984

Total michigan waters of Lake Huron creel+charter Chinook salmon harvest 1986-2012

102892 112652 127702 62572
89248 50043 49447 58553 85808 115369 103622 151261 112322 93979
79725 77982 153845 117650 68158 18365 19177 11685 9429 7306
6295 8157 11537

ONTARIO RECREATIONAL EFFORT AND HARVEST 1989-1999

VALUES PROVIDED BY LLOYD MOHR APRIL 2000

EFFORT - DIRECTED AT CHS AS MAIN SALMONINE TARGET - THESE ARE ROD HOURS

168843

115074 114390 116644 37980 37478 153744 107355 89915 141989 166713

HARVEST

7574

4689 5500 5490 3296 3585 10567 5581 5960 14851 15760

ASSUMED ONT/MI HARVEST RATIO IN YEARS BEFORE 1989 AND AFTER 1999 (BASED ON AVERAGE OF LATER YEARS)

0.0889

0.0433

RETURN TO SWAN WEIR BY AGE

AGES 1-5

1985-2012.

5491 3582 5865 1724 0

1944 12809 22461 1567 0

9081 7664 31098 3604 0

2819 6467 18308 3236 0

3082 3937 16135 6965 0

#1990s

2925 2076 10054 4466 0

632 1000 949 333 0

971 2489 1822 700 0

219 2091 2363 719 0

861 750 902 89 0

3837 12591 12244 1048 0

458 1206 1751 304 0

176 575 1469 208 0

286 748 632 109 4

432 1401 1579 223 5

#2000s

425 294 813 134 2

687 399 372 47 2

339 352 469 56 2

67	578	560	91	2
146	197	534	50	3
61	184	207	28	1
22	104	223	24	2
210	40	52	7	0
176	821	412	35	4
33	195	334	30	1
#2010s				
345	70	65	7	0
130	450	244	11	0
66	162	190	31	0

STOCKING AT SWAN RIVER WEIR FROM 1983 to 2011

770000 900209 734022 950268 909763 957768 1009142
945948 821783 778822 848484 902243 966725 900738 886161 817361 709169
770862 774842 661719 746428 745071 735403 476381 472955 460387 472629
469652 397700

STOCKING AT SWAN IN 2012 NOT USED

#341415

#Relative Proportion of fishing that occurs each month (Jan - Dec) in a year (used July as standard)

0.000
0.000
0.000
0.087
0.334
0.559
1.000
0.807
0.468
0.072
0.000
0.000

Lake Huron Rec Age Comp from Michigan Creel Survey, 1983-2012, ages 1-5

0.07904192	0.1640719	0.6718563	0.077844311	0.007185629
0.21085271	0.3581395	0.3596899	0.069767442	0.001550388
0.11013216	0.446696	0.3568282	0.078414097	0.007929515
0.06056701	0.2332474	0.5199742	0.18621134	0
0.09095238	0.2504762	0.4257143	0.23	0.002857143
0.12264151	0.2291105	0.3975741	0.230458221	0.020215633
0.05882353	0.2533937	0.3438914	0.312217195	0.031674208
0.08860759	0.2278481	0.4367089	0.234177215	0.012658228
0.14391144	0.2749077	0.396679	0.173431734	0.011070111
0.19275701	0.2873832	0.3598131	0.158878505	0.001168224
0.11896745	0.3041526	0.5331089	0.043771044	0

0.0403397	0.2590234	0.641189	0.059447983	0
0.12060779	0.2877493	0.4510921	0.140550807	0
0.23100616	0.3080082	0.4096509	0.04825462	0.003080082
0.09453197	0.4457831	0.3957368	0.0639481	0
0.0890411	0.3002283	0.4121005	0.196347032	0.002283105
0.09072165	0.3	0.4329897	0.175257732	0.001030928
0.14023211	0.3491296	0.3897485	0.119922631	0.000967118
0.09775967	0.4039375	0.3788187	0.112016293	0.007467753
0.15834768	0.404475	0.408778	0.028399312	0
0.02759277	0.5185538	0.4357755	0.017126546	0.000951475
0.05968586	0.4408377	0.4942408	0.005235602	0
0.02861685	0.3449921	0.5564388	0.069952305	0
0.0872914	0.2952503	0.4261874	0.187419769	0.003851091
0.1125	0.4145833	0.3666667	0.085416667	0.020833333
0.05910165	0.5437352	0.3687943	0.026004728	0.002364066
0.04884319	0.3830334	0.5244216	0.038560411	0.005141388
0.50764526	0.1926606	0.2538226	0.042813456	0.003058104
0.1637931	0.6551724	0.1781609	0.002873563	0
0.2478185	0.4118674	0.3141361	0.02617801	0

#Mature fish collected in July and August - Lake Huron Rec Age Comp from Michigan Creel Survey, 1986-2012, ages 1-5

Note that mature age comp starts in 1986 because N assessed for maturity very small in 1983-1985

0.0000	0.4286	0.5714	0.0000	0.0000
0.0000	0.0444	0.3222	0.6333	0.0000
0.0283	0.0472	0.1604	0.6415	0.1226
0.0000	0.0345	0.4138	0.5000	0.0517

#1990s

0.0000	0.0930	0.5116	0.3488	0.0465
0.1045	0.3881	0.2687	0.2090	0.0299
0.0000	0.4000	0.4800	0.1200	0.0000
0.0000	0.1231	0.5538	0.3231	0.0000
0.0000	0.2167	0.6333	0.1500	0.0000
0.1033	0.2030	0.5572	0.1365	0.0000
0.1917	0.3458	0.4083	0.0542	0.0000
0.0000	0.1324	0.6961	0.1716	0.0000
0.0061	0.1152	0.6303	0.2485	0.0000
0.0180	0.1655	0.5504	0.2626	0.0036

#2000s

0.0000	0.0970	0.7313	0.1642	0.0075
0.0093	0.2430	0.4704	0.2741	0.0031
0.0457	0.3514	0.5571	0.0457	0.0000
0.0068	0.2901	0.6689	0.0307	0.0034
0.0166	0.3278	0.6515	0.0041	0.0000
0.0000	0.2879	0.5985	0.1136	0.0000
0.0100	0.2742	0.4849	0.2274	0.0033
0.0265	0.3510	0.4834	0.1126	0.0265

0.0276 0.4552 0.4828 0.0345 0.0000
0.0185 0.3333 0.5833 0.0556 0.0093
#2010s
0.1972 0.2958 0.3944 0.0986 0.0141
0.0500 0.7000 0.2400 0.0100 0.0000
0.0522 0.3433 0.5373 0.0672 0.0000

SAMP SIZES FOR OBSERVED AGE COMP FOR REC FISHERY 1983-2012

835	645	1135	1552	2100	742	221			
158	542	856	891	471	1053	974	1079	876	970
1034	1473	1162	1051	955	629	779	480	423	389
327	348	573							

SAMP SIZES FOR OBSERVED AGE COMP FOR MATURE FISH IN REC FISHERY

14	180	106	116						
43	67	25	65	60	271	240	204	165	278
134	321	350	293	241	132	299	151	145	108
71	100	134							

#Test values
-7777 -8888 -9999