Great Lakes Fishery Commission
Lake Michigan Committee Meeting
Windsor, Ontario
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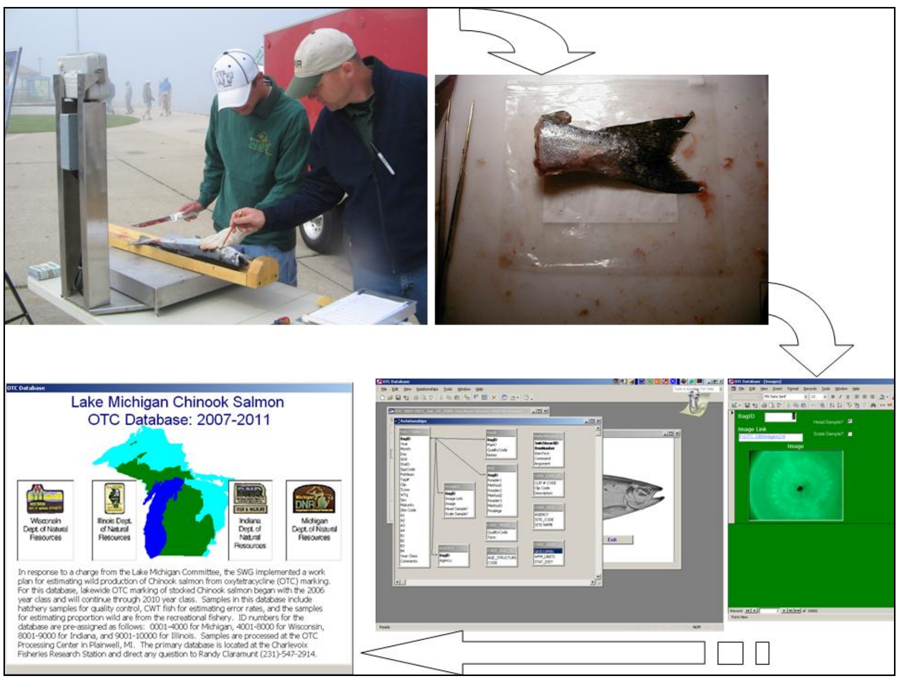
Status of Lake Michigan Salmonines in 2009: a Report from the Salmonid Working Group



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(Report considered as draft because it has not been fully reviewed by Salmonid Working Group or the Lake Michigan Technical Committee)

Introduction

The Fish Community Objective (FCO) for Lake Michigan salmonines specifies establishment of a diverse salmonine community capable of sustaining an annual harvest of 2.7 to 6.8 million kg, of which 20-25% is lake trout *Salvelinus namaycush*. Inherent in this objective is the desire to maintain a salmonine community that has abundant levels of Chinook salmon *Oncorhynchus tshawytscha* (i.e., target annual yield of 3.1 million kg) sufficient to suppress alewife *Alosa pseudoharengus* populations but not beyond levels where predator consumption would threaten food web integrity.

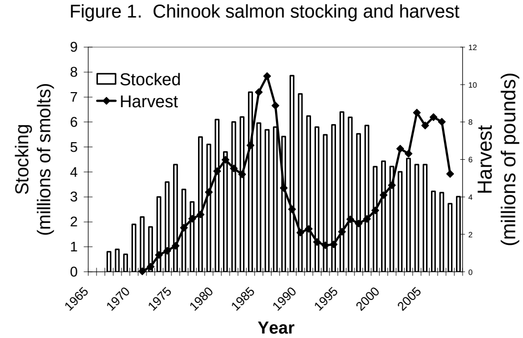
The Salmonine and Planktivore Objectives are based on the understanding that large populations of exotic forage fishes, such as alewife and rainbow smelt *Osmerus mordax*, negatively impact recruitment of native fishes, and that controlling exotic prey fishes presents an opportunity to create new, diverse fishing opportunities. Therefore, progress toward these objectives is evaluated by determining the relative balance between predator and prey (e.g., Chinook salmon and alewife interactions) rather than suppression of alewife through extreme top-down predation.

Through the Lake Michigan Technical Committee (LMTC) process, a Salmonid Working Group (SWG) was established to cooperatively collect and disseminate knowledge regarding Lake Michigan salmonines and to assess the status of pelagic salmonines and their prey (Terms of Reference for the Salmonid Working Group 2008).

The SWG's main goal is to evaluate progress toward achieving the Salmonine FCO, and is accomplished by implementing a science-based approach for annually evaluating measurable indices of the salmonine and planktivore populations (i.e., Red Flags). This evaluation, along with consultation with managers and constituents, has resulted in two (1999 and 2006; Figure 1) coordinated lakewide stocking reductions.

Prior to the analysis of the 2009 data presented herein, the SWG would make a recommendation regarding progress towards meeting the Salmonine FCO based on an *a priori* set of criteria and benchmarks (see “Methods” section). Per discussions at the 2009 LMTC summer meeting, however, the SWG has modified its methods for evaluating the Salmonine FCO because it was determined that the LMTC will be responsible for making any formal recommendation to the managers on the Lake Michigan Committee (LMC). Therefore, the SWG will limit its role to calculating biological indicators and the LMTC, upon review, will determine whether or not management recommendations are necessary based, in part, on the results of the Red Flags analysis.

Figure 1. Chinook salmon stocking and harvest



Methods

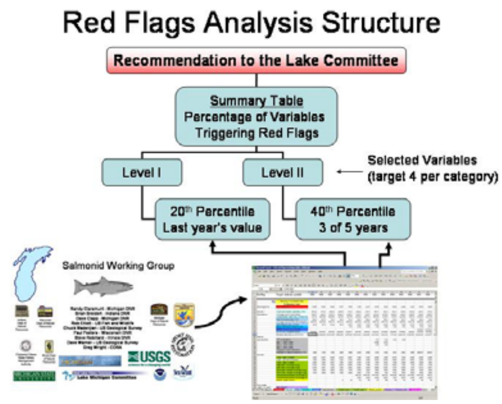
The SWG uses a set of criteria to measure the health of the Chinook salmon population and identify potential threats to predator-prey populations. The biological criteria utilize all currently available data from ongoing assessments, including: estimates of **abundance** from creel and fishery-independent surveys, stocking records and estimates of **natural reproduction**, estimates of salmonine size-at-age and **growth**, trends in **prey fish abundance**, and indices of fish **health** and system **integrity**. For each biological category, we have several indices available for analysis. However, we have selected only a few representative parameters from each category to present here.

Similar to the results from previous years, we used the frequency distributions of the selected variables to indicate when values for the current year (Level I) or three of the previous five years (Level II) are outside an acceptable range. Evaluated parameters indicate imbalance (i.e., trigger red flag) when:

- **Level I**: A value from the most recent year of data that is lower than the 20th or higher than the 80th percentile will trigger a red flag.

- **Level II**: Values from three out of the last five years which are lower than the 40th or higher than the 60th percentile will trigger a red flag.

Through this annual report, the SWG shares the results of the level I and II indicator analysis with the LMTC for their consideration in making recommendations (e.g., changing stocking rates or fishery regulations) to the LMC for salmonines in Lake Michigan.



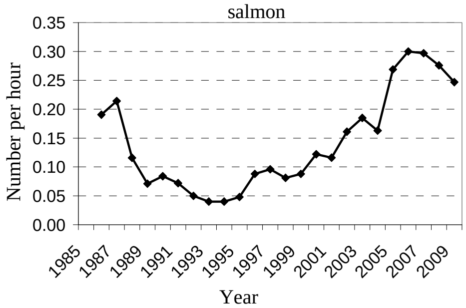
The data included in this report are provided by several agency and university sources (see diagram above). Members of the SWG assist in the collection and/or consolidation of such data by providing summary statistics in a lakewide time-series table. The data in the table cover 1985-present and are used herein to evaluate the overall predator-prey balance necessary to achieve the Lake Michigan Salmonine Objective.

Results and Discussion

Abundance: Charter fishery catch rates, predicted abundance of age-1 fish, and Michigan's weir returns were utilized to evaluate trends in Chinook salmon abundance in 2009. Chinook salmon are used as the indicator of overall predator abundance because of the availability of data and because of the demand placed on the prey population due to their high consumption rate. Lakewide harvest of Chinook salmon was highest in the late 1980s, declined substantially during 1989-1994, increased steadily from 1995-2005 and remained high through 2007, but dropped substantially in 2008 (Figure 1).

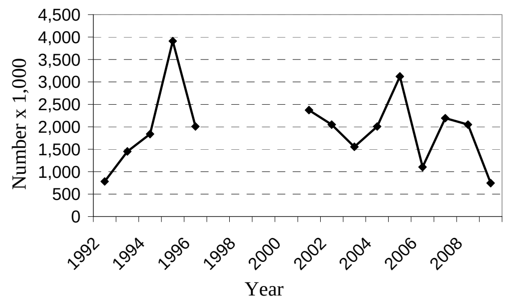
Similarly, catch rates in the recreational fishery, using Michigan DNRE charter CPE as an index, declined in the late 1980s, were low during 1992-1994, but have been rising since 1995 until 2007-2009 (Figure 2). Charter catch rates declined from 29.7 fish per 100 hours in 2007 to 27.6 in 2008 and 24.7 in 2009. Average catch rate over the entire time series is 14.1±1.7 and ranged from 4.0 – 30.0 fish per 100 hours of fishing (Table 1). Even though catch rates declined in 2008 and 2009, they are still above the long-term average. Previous SWG reports predicted the observed decline because recreational catch rates had been at all-time high levels during 2006-2007 (30 fish and 16.0 fish per 100 hours for the charter and non-charter fisheries, respectively; Claramunt et al. 2008, 2009).

Figure 2. Fishery (charter) catch rates for Chinook salmon



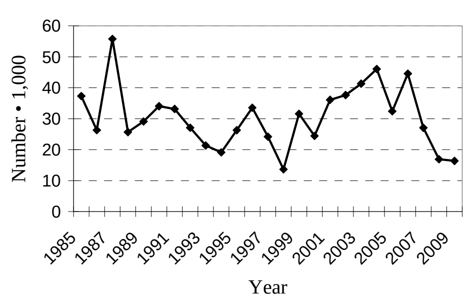
The abundance of age-1 Chinook salmon can be predicted from the abundance of age-0 alewives in the previous year (Warner et al. 2008). Based on that relationship, we used the abundance of age-1 Chinook salmon as an index of future salmon abundance because fishery-independent survey collections were not available in 2009. The abundance of age-1 Chinook salmon showed an increasing trend in the early part of the time series (1992-1996; Figure 3). Since 2005, however, the predicted abundance of age-1 Chinook salmon indicates a decreasing trend (Figure 3). In 2009, the predicted number of age-1 Chinook salmon was below the average of 1,942,140 ± 227,625 fish and the lowest in the time series at 745,600 fish.

Figure 3. Number of age-1 Chinook salmon



The predicted decrease in abundance of age-1 Chinook salmon is supported by the sharp declines seen in returns to Michigan's weirs (Figure 4). Weir returns dropped to 16,369 fish; the second lowest return in the weir time series. The drop in weir returns may be due to lower survival of older age classes, but it is more likely that these declines are from reductions in Chinook salmon recruitment (see "Reproduction" section below). With the exception of the level I indicator for charter catch rates, all of the Chinook salmon abundance indicators triggered both level I and II red flags (Table 1).

Figure 4. Michigan Weir Returns

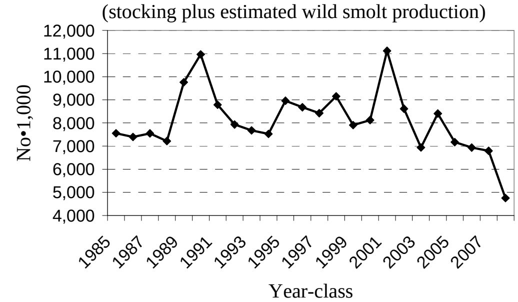


Reproduction: Recruitment of naturally-produced Chinook salmon smolts has increased since their introduction in 1967. Natural reproduction has been estimated periodically throughout the period 1985-2009. Estimates in the early 1990s from oxytetracycline (OTC) studies suggested that natural recruitment accounted for 29-35% of lakewide adult stocks when stocking levels were near their highest (6-7 million smolts; Figure 1 and 5).

Estimates for 2001-2003 from OTC-marked fish collected in 2004 and, more recently, estimates from the lakewide OTC evaluation starting with the 2006 year-class (Claramunt et al. 2007), indicate that natural recruitment has increased such that natural recruits now account for over 50% of the lake population (Table 1) on average. For example, the percent of wild Chinook salmon for the 2006 and 2007 year-class was 54.0 % and 52.8 %, respectively. However, the percent of wild Chinook salmon dropped to 42.7% for the 2008 year-class (estimated from 2009 collections and unadjusted for marking error). In addition, estimates of total smolt production (estimates of natural reproduction and hatchery stocking combined at 4.8 million smolts) have declined to the lowest value since 1985.

The decline in Chinook salmon smolt production could be due to, in part, stocking reductions aimed at reducing total Chinook salmon abundance to be more in alignment with prey abundance. In addition to stocking reductions, wild smolt production has likely declined from reduced egg production as a function of smaller-sized females in the recent time series (see "Growth" section for more detail). Because estimates of the total number of Chinook salmon recruits entering the lake is at all-time lows (since 1985), and contribution from wild production appears to have been declining, the variables for natural reproduction triggered level I and II red flags, with the exception of percent OTC marked for level I (Table 1).

Figure 5. Total Chinook salmon recruitment (stocking plus estimated wild smolt production)



Growth: Several weight-at-age indices suggest that growth conditions have changed over time, presumably from changes in Chinook salmon abundance, forage levels, and environmental factors. For this report, we selected Chinook salmon weight-at-age 2 from the Michigan DNRE creel survey (male and female combined; Figure 6), weight-at-age 3 (females only) from Strawberry Creek (WI) weir returns (Figures 7), and the standard weight index (again from the Strawberry Creek weir; Figure 8) to assess changes in growth (Table 1).

Figure 6. Chinook salmon weight-at-age 2

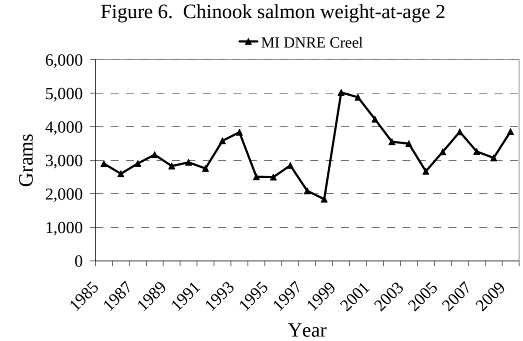
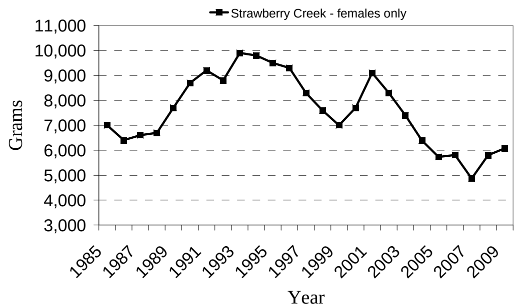
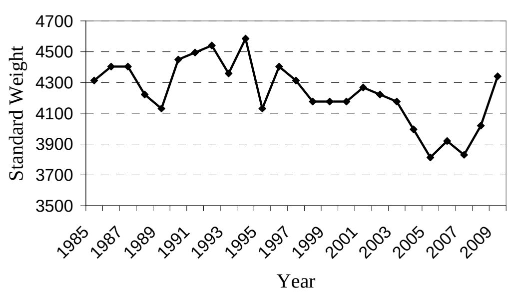


Figure 7. Chinook salmon weight-at-age 3



Most of the data sources indicate that weight-at-age peaked in 2000-2001, following the production of an abundant year-class of alewife in 1998, and declined from 2002 through 2007. In 2009, however, creel survey weight-at-age increased for age-2 to 3,850 grams (g) from 3,070 g in 2008. Average weight-at-age 2 from the creel was 3,180±154 g and ranged from 1,842-5,021 g throughout the time series (Figure 6; Table 1).

Figure 8. Chinook salmon standard weight index



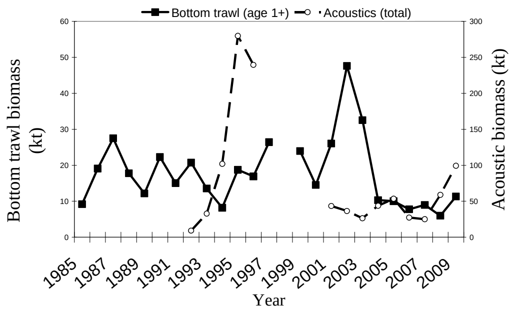
In 2009, weight of age-3 Chinook salmon increased at the Strawberry Creek weir (6,080 g) compared to 2008 (5,800 g). With respect to the long term average, weight-at-age 3 was still lower than the average of 7,587±290 g. Also, the standard weight index in 2009 (4,340 g) increased from 2008 (4,020 g), but was still below the average for the time series of 4,235±42 g (Figure 8). Weight-at-age indicators improved in 2009 so that only weir weight-at-age 3 triggered level I and II red flags and standard weight triggered a level II red flag (Table 1).

Prey fish abundance: Estimates of forage fish biomass are reported in kilotonnes (kt; 1 kt = 1,000 metric tons) of age-1 and older alewife from bottom trawl surveys and in kt of total alewife biomass from acoustic surveys (Figure 9). Average biomass from bottom trawl surveys is 17.8±2.0 kt, ranging from 6.0-47.6 kt during 1985-2009 (Table 1; Madenjian et al. 2010). Alewife biomass estimated from the bottom trawl increased from 6.0 kt in 2008 to 11.3 kt in 2009. Alewife biomass in 2008, however, was the lowest value in the time series (1985-2009; Table 1).

In contrast, alewife biomass estimated from acoustic surveys in 2009 was 99.2 kt and above the long-term average of 76.9±22.0 (1992-1996 and 2001 – 2009; Figure 9). Even though the acoustic estimate of alewife biomass was high in 2009, it remains below values recommended in the Planktivore FCO (Warner et al. 2010).

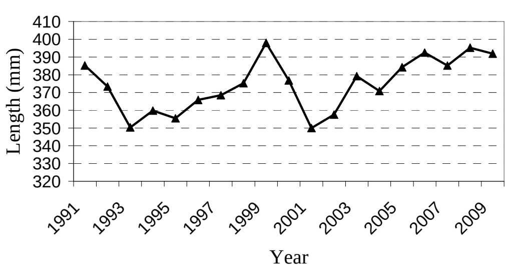
These data suggest that the increase in abundance of alewives can be attributed to an increase in older, larger age classes and not from increases in recruitment. The results from the acoustic survey, which is very efficient at sampling younger ages of alewives (ages 0-2), suggests that the abundance of young alewives in 2009 is low (Warner et al. 2010). Both bottom trawl and acoustic estimates of alewife biomass triggered level II red flags in 2009.

Figure 9. Lakewide alewife biomass



In previous reports, we used alewife abundance in predator diets as another indicator of changes in prey abundance. Unfortunately, long-term trends of predator diet samples (grams of total prey in stomach) are no longer available. As a replacement for an index of diet conditions, we used the average length of a jack coho salmon (age-1 males) returning to Michigan weirs because their growth represents prey availability in one growing season only. Changes in the length of a coho jack should be closely related to changes in alewife abundance, or at least juvenile alewife abundance. Similar to previously reported results for trends in Chinook salmon diets/ration, coho lengths were low in the mid 1990s, peaked following the strong 1998 year-class of alewife, declined, but then recovered following increases in production of alewives starting with the 2002 year-class (Figure 10). Average length of a coho jack for 1991-2009 was 374±3.5 mm and ranged from 350 to 398 mm (Table 1).

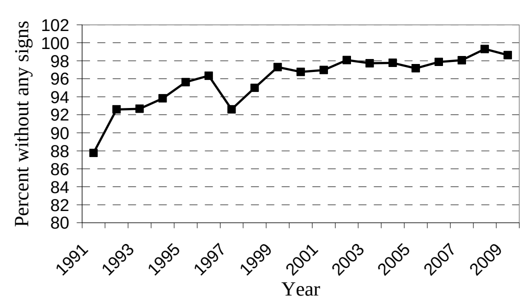
Figure 10. Mean length of a coho jack returning to Michigan weirs



The increase in coho length may also be impacted by reduced competition with Chinook salmon (Chinook salmon recruitment has been low), which will indirectly affect the predator-prey ratios for coho salmon. In 2009, the average length of a coho jack continued a several year trend of increasing length and was extremely high (392 mm), suggesting that an abundance of alewives vulnerable to coho predation currently exists in Lake Michigan. However, a level II red flag was triggered because the values were above of the acceptable range (Table 1).

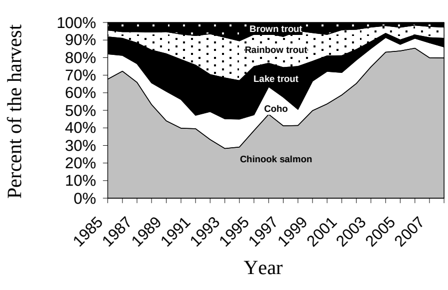
Fish health: Fish health has been monitored using several tests (e.g., visual signs, FELISA, QELISA, DFAT) for the presence of *Renibacterium salmoninarum*, the causative agent for bacterial kidney disease (BKD). Stress-mediated diseases such as BKD can have strong regulatory influences on Chinook salmon populations. Additionally, using consistent methods, gross clinical (visual) signs of disease have been recorded for fish captured in the open-water survey and for weir returns. Critical information from the fishery-independent survey is no longer available. Less than 1.5% of the weir-returning Chinook salmon showed any sign of disease in 2009, and no red flags were triggered (Figure 11; Table 1).

Figure 11. Visual signs of disease from weirs



System Integrity: In 2008, the SWG was asked by the Lake Michigan Committee to incorporate additional indicators for other salmonines such as brown trout, coho salmon, steelhead, and lake trout. With the additional indicators, the red flags analysis could be expanded to evaluate the objective to maintain diversity in the predator-prey complex with the view of promoting ecosystem integrity. In response to the LMC request, we used the proportion of the harvest that was comprised of the other (not Chinook salmon) salmonines and evaluated the trend using the red flags approach. The recommended composition in the Salmonine Objective (interpreted from the recommendations for total harvest by salmonine) is 50% Chinook salmon and 20-25% lake trout. The average percent of the harvest over the 1985-2008 time series (2009 data not yet available) that is comprised of salmonines other than Chinook salmon is 43.5±3.8 % (Table 1). However, the percent composition was low in 2008 (20.2%) and has been low for several years (2009 data not available; Figure 12). The percent composition of the harvest for the other salmonines triggered a level II red flag based on 2008 harvest.

Figure 12. Composition of the lakewide harvest

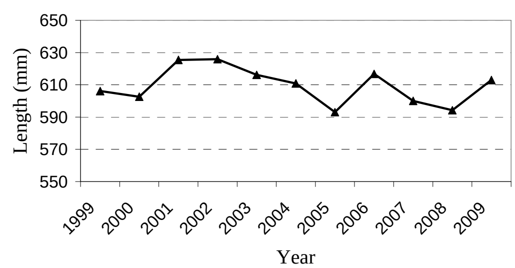


Summary

Chinook salmon stocking rates were adjusted in 1999 and 2006, through a cooperative process, in an attempt to minimize the risk of a lakewide salmon population crash and its effects on the fishery. These stocking reductions were based on a review of biological indicators from the SWG and reflected the consensus of fisheries managers from each agency. To assist in this management process, the SWG is committed to including new indicators (e.g., the addition of coho trends) and continuing the ongoing collection and consolidation of lakewide time series data on salmonines in Lake Michigan.

The SWG would like to incorporate additional trends for lake trout (e.g., trends in lakewide egg thiamine levels, abundance, growth, and age structure) for the health and integrity section of the Red Flag analysis. For example, the mean length of an age-5 lake trout from northern Lake Michigan has remained relatively stable given the magnitude of changes in Chinook salmon and alewife biomass (Figure 13; data provided by Jory Jonas and the Lake Trout Working Group).

Figure 13. Mean length of an age-5 lake trout from northern Lake Michigan



Chinook salmon harvest in 2004-2007 was above the established reference level set forth in the Salmonine Objective for Lake Michigan (3.1 million kg / 6.8 million pounds; Figure 1), but dropped substantially to within the Salmonine Objective range in 2008. This observation was expected based on our analysis of the 2007 Red Flag parameters, from which the SWG concluded that the previous harvest levels were not sustainable and declines in fishery catch rates and harvest levels in the near future were inevitable. Indicators of salmon abundance suggested that the decline starting in 2008 would continue in 2009 and likely into the 2010 fishing season. Because of the fluctuations in Chinook salmon abundance, alewife biomass has been increasing and the frequency distributions of many of the selected parameters were outside of the acceptable ranges for level II (the trend indicator). However, many of the level I indicators that were triggered in 2008 were not triggered in 2009, suggesting that predator-prey ratios are more in balance. In addition, as Chinook salmon abundance has declined, there is evidence of natural feed-backs in the system as wild production of Chinook salmon has decreased and alewife biomass has increased, likely from reduced predation pressure.

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Table 1. Selected red flag variables; data in this summary table were collected during the period 1985-2009.

Biological Variable	Min	Max	Mean	SE	2009 Values	Current Year Level I Acceptable Range	Current Year Level I Red Flag[1]	Three Out of Five Years Level II Acceptable Range	Three Out of Five Years Level II Red Flag[1]
Abundance									
Charter CPE (n per 100 hrs)	4.0	30.0	14.1	1.7	24.7	7.1 – 24.7	No *	8.8 – 16.1	**Yes**
Age-1 abundance (x 1 million)	0.75	3.91	1.94	0.2	0.75	1.1 – 2.4	**Yes***	1.8 – 2.0	**Yes***
MI weir returns (n x 1000)	13.6	55.8	30.4	2.0	16.4	21.9 – 37.6	**Yes**	26.6 – 32.9	**Yes**
Natural Reproduction									
Percent unmarked (OTC)	23.0	65.8	44.1	3.6	42.7	32.2 – 53.4	No	41.7 – 48.3	**Yes**
Total Recruits (n x 1 million)	4.8	11.1	8.1	0.3	4.8	7.2 – 9.0	**Yes**	7.6 – 8.4	**Yes**
Growth Indices									
Creel weight-at-age 2 (g)	1,842	5,021	3,180	154	3,850	2,641 – 3,850	No	2,903 – 3,258	No*
Weir weight-at-age 3 (g)	4,870	9,900	7,587	290	6,080	6,142 – 9,180	**Yes**	7,000 – 8,060	**Yes**
Standard weight (g)	3,814	4,585	4,235	42	4,340	4,042 – 4,404	No	4,177 – 4,313	**Yes**
Prey fish Abundance									
Acoustic biomass (kt)	9.1	279.8	76.9	22.0	99.2	26.3 – 101.9	No*	36.4 – 53.5	**Yes**
Bottom trawl (kt)	6.0	47.6	17.8	2.0	11.3	9.2 – 26.1	No*	13.5 – 18.7	**Yes**
Length of coho jacks (mm)	350	398	374	3.5	392	358 – 392	No*	371 – 379	**Yes**
Health and Integrity									
Other[2] salmonine harvest (%)	14.6	71.7	43.5	3.8	20.2	20.2 – 60.5	No*	34.8 – 52.3	**Yes**
Visual Signs - Weir (%w/o)	87.8	99.3	95.9	0.7	98.6	97.3 – 100	No	98.1 – 100	No

[1]Yes = data outside of acceptable range. [2] = Other than Chinook salmon.
* =A change in the Red Flag from the previous survey year.