Predator/Prey Ratio Analysis (PPR)

Salmonid Working Group:
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- Jory Jonas, Ben Turschak, Mark Tonello (MI DNR)
- Nick Legler (chair), Iyob Tsehaye (WI DNR)
- Brian Breidert, Ben Dickinson (IN DNR)
- Steve Robillard (IL DNR)
- Chuck Bronte, Matt Kornis, Rob Elliott (USFWS)
- Richard Clark (QFC, MSU)

Key Collaborations:
- Great Lakes Fishery Commission
- Lake Michigan Committee
- Planktivore Working Group
- USFWS Mass Marking Program
- Several agencies & personal provided input, data, etc.
- QFC at MSU
- Randy Claramunt
Chinook Total Lake Biomass ÷ Alewive Total Lake Biomass = P/P Ratio
Chinook Total Lake Biomass \[\div\] Alewive Total Lake Biomass = \[\text{P/P Ratio}\]

Chinook / Alewive (PPR)

Year X

Maybe stock more fish?

Low Ratio

Year Y Year Z

(Hypothetical Data)
Chinook Total Lake Biomass \( \div \) Alewif Total Lake Biomass = P/P Ratio

Chinook / Alewif (PPR)

Year X Year Y Year Z

(Hypothetical Data)

High Ratio

Maybe stock less fish?
Chinook Total Lake Biomass ÷ Alewife Total Lake Biomass = P/P Ratio

Chinook / Alewife (PPR)

Year X  Year Y  Year Z

(Hypothetical Data)

Intermediate
Chinook Total Lake Biomass ÷ Alewive Total Lake Biomass = P/P Ratio

(Hypothesised Data)
Statistical Catch at Age Model (SCAA)

- Number stocked
- Number wild
- Angler hours
- Angler harvest
- Weir age composition
- Weight-at-age at harvest/spawn
- Weight-at-age at annulus formation
- Standard weight of 35 inch Chinook

Abundance by age for Chinook salmon → Biomass

Number of Chinook Fingerlings Stocked into Lake Michigan (1967-2017)

- Peak: 7.8 million in 1989
- 1.37 million in 2017

Stocking Reductions:
- 1986
- 1992
- 1998
- 2006
- 2013
- 2017
Recent estimates of % wild at age 1 have consistently been around 50% (e.g., high 2013 = 64.8%; low 2014 = 38.6%).
Recently, about 600,000 to 700,000 Chinook salmon have been stocked into northern Lake Huron, & about 95% have traveled to Lake MI annually.
Number of Chinook Stocked into Lake MI

Targeted Salmonine Boat-Only Effort for Lake MI
(hours fished)
Number of Chinook Stocked into Lake MI

decreasing since the 1980’s

Targeted Salmonine Boat-Only Effort for Lake MI
(hours fished)

Numbers of Chinook Harvested for Lake MI
Number of Chinook Stocked into Lake MI

Targeted Salmonine Boat-Only Effort for Lake MI
(hours fished)

Numbers of Chinook Harvested for Lake MI
Number of Chinook Stocked into Lake MI

Targeted Salmonine Boat-Only Effort for Lake MI (hours fished)

Numbers of Chinook Harvested for Lake MI

80s & 90s

decreasing since the 1980’s
Number of Chinook Stocked into Lake MI

- Decreasing since the 1980’s

Targeted Salmonine Boat-Only Effort for Lake MI (hours fished)

Numbers of Chinook Harvested for Lake MI

- Targeted Salmonine Boat-Only Effort for Lake MI (hours fished)

- Numbers of Chinook Harvested for Lake MI

- Year bars show the number of fish targeted, harvested, and stocked over the years from 1985 to 2017.
Number of Chinook Stocked into Lake MI

- Decreasing since the 1980’s

Targeted Salmonine Boat-Only Effort for Lake MI
(hours fished)

Numbers of Chinook Harvested for Lake MI

- 2005 = 843,969 (1st highest)
- 2012 = 708,905 (6th highest)
Angler photo from 2012: lots of Chinook salmon caught...
Angler Caught Chinook – Lake MI, July 30, 2012

- Chinook Salmon
- Delivered to Nick Legler in Sturgeon Bay on Aug 1, 2012.
- Caught by charter angler on L. MI 3E near Whitefish Point on July 30.
Number of Chinook Stocked into Lake MI

Targeted Salmonine Boat-Only Effort for Lake MI (hours fished)

Numbers of Chinook Harvested for Lake MI

2017 = 149,442
Statistical Catch at Age Model (SCAA)

- Number stocked
- Number wild
- Angler hours
- Angler harvest
- Harvest age composition
- Weir age composition
- Weight-at-age at harvest/spawn
- Weight-at-age at annulus formation
- Standard weight of 35 inch Chinook

Abundance by age for Chinook salmon

Biomass


Recent stocking reduction decisions years:
- 1998 = 25%
- 2005 = 25%
- 2012 = 50%
- 2016

Age 1
Age 2-5

stocking reduction decision years

(Chinook salmon stocking reduction decision years in yellow)

(Chinook salmon stocking reduction decision years in yellow)

Record high in 2013 = 14.4 kt

(Chinook salmon stocking reduction decision years in yellow)

2015 = 3.5 kt
2017 = 4.7 kt

(Chinook salmon stocking reduction decision years in yellow)
Chinook Total Lake Biomass \(\div\) Alewive Total Lake Biomass = P/P Ratio

Chinook / Alewive (PPR)

Year X \(\div\) Year Y \(\div\) Year Z
Statistical Catch at Age Model (SCAA)

Eat at Age

Alewife abundance (trawl, hydro-acoustic)

Weight-at-age for prey / alewife proportion by age (trawl)

Alewife abundance by age for Alewife

Biomass by age for Alewife

Number of salmon & trout stocked

Predator abundance

Total consumption by predators
This figure shows consumption of all prey species.
Predator Consumption Estimates
(Chinook updated through 2017)

This figure shows consumption of all prey species.

Chinook = dominant consumer
This figure shows consumption of all prey species.

Chinook consumption down, following stocking reductions...

Predator Consumption Estimates
(Chinook updated through 2017)

- Chinook salmon model underlying methods (2014)
  & routine data updates (annual)
- Other predator models.....
Statistical Catch at Age Model (SCAA)

Eat at Age

Alewife abundance
(trawl, hydro-acoustic)

Weight-at-age for prey / alewife proportion by age (trawl)

USGS forage surveys

Abundance by age for Alewife

Biomass by age for Alewife

Number of salmon & trout stocked

Predator abundance

Total consumption by predators
Forage Biomass = LOW!

Bottom Trawl adult (≥ 100 mm length) alewife age/length composition in 2013

2013 prey fish composition
Ecosystem: Bottom Up & Top Down

Stocked  Wild  Stocked  Wild

[Images of stocked and wild fish]

- Below average since 2004, past 14 years
- Below 100 kt past 3 years

Maximum: 242 kt

Minimum: 100 kt

(Chinook salmon stocking reduction decision years in yellow)
Total Lake Wide Chinook Biomass

÷

Total Lake Wide Alewife Biomass

= PPR

(through 2015)
Chinook/Alewife Ratio
(past results, to 2015)

Criteria to develop limits include: examples from other lakes (Huron), literature review, risk assessment, & energy conversion efficiency.
Lakes Michigan & Huron
Note: 95% of the >600K Chinooks stocked recently into northern Lake Huron have traveled to Lake Michigan.
USGS Lake-wide Annual Forage Surveys

Lake Huron vs. Lake Michigan
In Lake Huron, the alewife population ‘collapsed’ in 2003.

Following a 5 year period (1998-2002) during which the estimated PPR for Chinook/alewife averaged 0.11 (0.12, 0.13, 0.11, 0.11, 0.10)

Subsequently, the Chinook salmon population ‘collapsed’ in 2006.
Chinook/Alewife Ratio
(past results, to 2015)

Upper Limit = 0.10
Target = 0.05

2015 = 0.108
2013 = 0.1
Chinook/Alewife Ratio

(past results, to 2016)

Year

Chinook/Alewife Ratio

Upper Limit = 0.10

Target = 0.05

2016 PPR = .07
 stil above target
Chinook/Alewife Ratio

(past results, to 2016)

Upper Limit = 0.10
Target = 0.05

PPR for 2015:
2015 model = 0.108
2016 model = 0.053

Uncertainty
Basic explanation
Total Lake-wide Biomass of Chinook Salmon Ages ≥1 (1967-2016)
Total Lake-wide Biomass of Alewife Ages ≥1 (1967-2016)
Total Lake-wide Biomass of Alewife Ages ≥1 (1967-2016)

Zoom in, to 2010 - 2016
Total Lake-wide Biomass of Alewife Ages ≥1 (1967-2016)

- 2015 Model
- 2016 Model

- 2010: 150 kt
- 2011: 200 kt
- 2012: 225 kt
- 2013: 200 kt
- 2014: 150 kt
- 2015: 75 kt
- 2016: 37 kt
- 2017: Unknown

- Biomass (kt)
PPR for year **2015**, based on **2015 model run**:

\[
\frac{3.98 \text{ kt Chinook}}{36.8 \text{ kt Alewife}} = 0.108 \text{ PPR}
\]

PPR for year **2015**, based on **2016 model run**:

\[
\frac{3.8 \text{ kt Chinook}}{75.3 \text{ kt Alewife}} = 0.051 \text{ PPR}
\]
PPR for year 2015, based on 2015 model run:

\[
\frac{3.98 \text{ kt Chinook}}{36.8 \text{ kt Alewife}} = 0.108 \text{ PPR}
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PPR for year 2015, based on 2016 model run:

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PPR for year 2015, based on 2016 model run:

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PPR for year 2015, based on 2016 model run:

\[
\frac{3.8 \text{ kt Chinook}}{75.3 \text{ kt Alewife}} = 0.051 \text{ PPR}
\]
Chinook/Alewife Ratio
(most recent results to 2017)

Upper Limit = 0.10
Target = 0.05

Similar, but slightly lower PPR compared to last year.

Chinook Biomass (kg)

Alewife Biomass (kt)

Overall similar patterns...

Chinook Salmon
Biomass for 2016:
2016 model = 5.0 kt
2017 model = 4.8 kt

Alewife
Biomass for 2016:
2016 model = 67 kt
2017 model = 86 kt (19 kt more)
Chinook/Alewife Ratio
(most recent results to 2017)

Upper Limit = 0.10
Target = 0.05

Alewife Biomass for 2016:
2016 model = 67 kt
2017 model = 86 kt
(19 kt more)

PPR for 2016:
2016 model = 0.74
2017 model = 0.056
• Somewhat positive & encouraging...
• But, alewife biomass still record low & PPR above target

Upper Limit = 0.10
Target = 0.05

2017 PPR = .058
2016 PPR = .056
2015 PPR = .051
Auxiliary Indicators
Updated with 2017 Data

• Average weight of age 3 female Chinook salmon

• Standard weight of 35 inch Chinook salmon

• Targeted harvest of Chinook salmon by charter boats

• Lake-wide sport harvested weight by species
Average Weight of Age 3 Female Chinook Salmon from Fall Spawning Surveys
2017 Samples Sizes for Calculating Average Weight of Age 3 Female Chinook (from fall spawning surveys)

<table>
<thead>
<tr>
<th>Location / Weir</th>
<th>Number of Age 3 Female Chinooks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boardman, MI</td>
<td>31</td>
</tr>
<tr>
<td>Little Manistee, MI</td>
<td>42</td>
</tr>
<tr>
<td>Medusa Creek, MI</td>
<td>11</td>
</tr>
<tr>
<td>Harbors, IL</td>
<td>28</td>
</tr>
<tr>
<td>Root Weir, WI</td>
<td>80</td>
</tr>
<tr>
<td>BAFF Weir, WI</td>
<td>412</td>
</tr>
<tr>
<td>Strawberry Creek, WI</td>
<td>327</td>
</tr>
</tbody>
</table>

total = 931
Average Weight of Age 3 Female Chinook (1986-2017)

2017 = 17.8 pounds

All states combined

Bordman, MI
Strawberry Creek, WI
Little Manistee, MI
Harbors, IL
Medusa, MI
BAFF & Root, WI (2016 only)
Average Weight of Age 3 Female Chinook (1986-2017)

Bordman, MI
Little Manistee, MI
Medusa, MI
Strawberry Creek, WI
Harbors, IL
BAFF & Root, WI (2016 only)

Avg = 15.5 lbs

1990 - 1996
Above average & relatively high weights (~18-19 lbs.)

2013, 2016, 2017

Avg = 15.5 lbs

Many below average weights, including 13 of the past 16 years

Avg = 15.5 lbs

Bordman, MI
Little Manistee, MI
Medusa, MI
Strawberry Creek, WI
Harbors, IL
BAFF & Root, WI (2016 only)
Average Weight of Age 3 Female Chinook (1986-2017)

X.X = difference in weight from one year to the next.

2012 = 11.8 lbs.
2013 = 18.9 lbs. (up 7.1 lbs.)

Average Weight of Age 3 Female Chinook (1986-2017)


Bordman, MI Little Manistee, MI Medusa, MI
Strawberry Creek, WI Harbors, IL BAFF & Root, WI (2016 only)

2012 = 11.8 lbs. 2013 = 18.9 lbs. (up 7.1 lbs.)

X.X = difference in weight from one year to the next.
Difference in Average Weight of Age 3 Female Chinook Salmon from Year to Year

<table>
<thead>
<tr>
<th>Year</th>
<th>1987 to 2012</th>
<th>2013 to 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>0.0</td>
<td>0.3</td>
</tr>
<tr>
<td>Max</td>
<td>3.1</td>
<td>7.1</td>
</tr>
<tr>
<td>Avg</td>
<td>1.1</td>
<td>3.9</td>
</tr>
</tbody>
</table>

Average Weight of Age 3 Female Chinook

- 2012 = 11.8 lbs.
- 2013 = 18.9 lbs.
- Jumped 7.1 lbs.
Average Weight of Age 3 Female Chinook (1986-2017)

Bordman, MI
Little Manistee, MI
Medusa, MI
Strawberry Creek, WI
Harbors, IL
BAFF & Root, WI (2016 & 2017 only)

Similar Patterns
Lake Huron – Swan River, Michigan
Standard Weight of 35 inch Chinook Salmon

- Creel & mass marking program Chinooks
- Sampled from anglers during July 1 to August 15
Simplified Example of Standard Weight
(2017 MI DNR Creel Data)

Length (inches)

Weight (pounds)

Standard Weight of 35” Chinook = 17.7 lbs.
Standard Weight of 35 inch Chinook Salmon Collected July 1 to Aug 15 (samples size for 2017)

Creel = 452
Mass Marking = 2,286
Total = 2,738
Standard Weight of 35 inch Chinook Salmon Collected July 1 to Aug 15 (2017 data)

Y axis = weight (lbs.)
X axis = length (in.)

IN - Mass Marking
IL DNR Creel
IL Mass Marking
MI DNR Creel
MI Mass Marking
WI DNR Creel
WI Mass Marking

2017 = 18.2 pounds

Year Avg. = 17.1 lbs.

1990s Above average & relatively high weights (~18-19 lbs.)
2011, 2013, 2017

Avg. = 17.1 lbs.

All states combined (creel & mass marking)

Avg. = 17.1 lbs.

Many below average weights, including 10 of the past 14 years

2012 = 14.5 lbs.
Difference in Standard Weight of 35 inch Chinook Salmon from Year to Year

<table>
<thead>
<tr>
<th>Year</th>
<th>1984 to 2010</th>
<th>2011 to 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>0.04</td>
<td>1.02</td>
</tr>
<tr>
<td>Max</td>
<td>2.03</td>
<td>3.94</td>
</tr>
<tr>
<td>Avg</td>
<td>0.84</td>
<td>2.36</td>
</tr>
</tbody>
</table>

In Lake Huron, the alewife population ‘collapsed’ in 2003.

Note: This slide is just state creel data. The lake-wide standard weight calculation in the previous slide included mass marking data.
Auxiliary Indicators
Updated with 2017 Data

• Average weight of age 3 female Chinook salmon

• Standard weight of 35 inch Chinook salmon

• Targeted harvest per hour of Chinook salmon by charter boats

• Lake-wide sport harvested weight (% composition by species)
Targeted **Harvest** of Chinook salmon (CHS) by Charter Boat Anglers

(i.e., number of Chinook salmon harvested)
Targeted **Harvest** of Chinook salmon (CHS) by Charter Boat Anglers (1990 – 2017)

**All States Combined**

- Avg = 103,779
- 2005 = 212,198
- 2006 = 220,710
- 2007 = 221,724
- 2012
- 2012 = 213,312
- Last 5 years (2013-2017)
- 2017 = 53,352
Targeted **Harvest** of Chinook salmon (CHS) by Charter Boat Anglers (1990 – 2017)

All States Combined

Avg = 103,779
Targeted Salmonine Effort by Charter Boat Anglers

(i.e., hours fished)
Targeted Salmonine **Effort** by Charter Boat Anglers (1999 – 2017)

- Avg. = 644,166 hours
- 2013 = 701,368 hrs.
- 2014 = 684,971 hrs.
- 2015 = 710,491 hrs.
- 2017 = 646,598 hrs.

avg. = 644,166 hours

all states combined

Wisconsin
Michigan
Illinois
Indiana

2004
Targeted Chinook Salmon (CHS)

**Harvest per Hour** by Charter Boat Anglers

(1990 – 2017)

\[
\text{Harvest} \div \text{Hour} = \text{CHS per hour}
\]
Targeted Chinook Salmon (CHS)

**Harvest per Hour** by Charter Boat Anglers

(1990 – 2017)

- Avg. = 0.16 CHS per hour
- > 0.3 CHS per hour
- 2005-2007
- 2012
- 2017

0.082 CHS per hour


Harvest Per Hour: 0.50, 0.40, 0.30, 0.20, 0.10, 0.00
Targeted Chinook Salmon (CHS) Harvest per Hour by Charter Boat Anglers (1990 – 2017)

Similar trends across all states.
Lake-wide Sport Harvested Weight by Species
Lake-Wide Sport Harvest in Pounds (1000s)

Chinook Salmon

Lake Trout

Rainbow Trout

Coho Salmon

Brown Trout

Total (all species)

(Notes: Y axis scales are not the same for each graph; data to 2017)

195K in 2006
812K in 2016
Summary – PPR

• Based on recent 2017 modeling:
  – PPR values for the past 3 years (2015-2017) were each just above the established target of 0.05 (i.e., 0.051, 0.056, 0.058). These PPR values are down, compared to a high of 0.09 in 2013.
  – Alewife biomass remains low & has been under 100 kt for the past 3 years.
  – Chinook biomass peaked at 14.4 kt in 2013, but since had declined following several stocking reductions, and was 4.7 kt in 2017.
Summary – Auxiliary Indicators

• Chinook salmon weights:
  – Have generally been below average for the past 15 years, although some recent years have produced big Chinooks, with high year-to-year variability in weights.

• Total harvest for Chinook salmon & harvest per hour has decreased since 2007.

• While sport harvested weight for Chinook salmon has decreased, harvest of lake trout has slightly increased.
A simple but important point about the PPR...

\[
\frac{14,744,683 \text{ kg Chinook salmon (like in 2013)}}{294,893,662 \text{ kg Alewife (hypothetical)}} = 0.05
\]

\[
\frac{3,980,384 \text{ kg Chinook salmon (like in 2015)}}{79,607,686 \text{ kgs Alewife (hypothetical)}} = 0.05
\]
Questions or feedback?

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Thanks again to everyone who contributed.

*A big thank you to the unofficial modeling team within the SWG for running the catch at age models & completing the PPR just last week.