GREAT LAKES FISHERY COMMISSION

2004 Project Completion Report[1]

Expanding the use of fish models for Lake Huron

by:

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Abstract

During the 2001 State of Lake Huron Symposium the Consumption Projection Model or CPM (formerly known as Consume) was identified as an important tool in evaluating progress toward Lake Huron Fish Community Objectives and helping define objectives for the future. While the first version of the model provided valuable insights into consumption by the key predators in Lake Huron, the model was limited to piscivore populations in the main basin. Incomplete coverage of Lake Huron and the lack of a coordinator to oversee annual updates limited the usefulness of the CPM. This project updated the model databases, and organized ongoing support for the model software and its databases. The CPM now includes (1) population databases for lake trout and Chinook salmon in Georgian Bay and the North Channel; (2) databases for lake whitefish and suckers, important hosts for sea lamprey, added to aid in future work; and (3) revisions to the Saginaw Bay walleye database to reflect recently available information. To improve accessibility to the CPM, PC-installable software, a new 75 page user manual, and a screen capture program now reside on an internet file server located at Michigan State University. A coordinator, responsible for annual database updates and as the first contact for software issues, has been appointed by the Lake Huron Technical Committee. These enhancements to the CPM and its ongoing support will improve its usability, making it a valuable tool for fisheries managers.

Enhancements to the CPM Model

Introduction

A major concern of fishery managers on Lake Huron has been the potential effects of over-stocking predators into the lake. Fishery managers on both sides of the lake continue to experience pressures to increase the stocking levels of other predators to potentially improve the quality of the sport fishery. Prey fish communities in Lakes Michigan and Ontario have experienced dramatic changes over the past 15 years that appear to be tied to predator impacts of stocked fish. The decline of alewife may have caused the collapse of the Chinook salmon fishery on Lake Michigan (Holey et al. 1998; Benjamin and Bence in press). Declines in alewife abundance in Lake Ontario led to a substantial reduction in stocking of salmonines into that lake. Models of the fish communities for these lakes including bioenergetics models (e.g., Stewart and Ibarra 1991; Rand and Steward 1998) and the "SIMPLE" model (Jones et al 1993) led to a better understanding of these ecosystems, while the use of the Lake Ontario model played a role in the decision to reduce stocking in that lake. Such models aid in determining whether consumption of prey fish by predators may exceed prey fish production (recruitment and growth). In 1992 the Lake Huron Committee charged the Lake Huron Technical Committee to investigate what would be the allowable level of stocking for all fish predators. Development of fish population and/or community models to project predator abundance and consumption of prey was clearly part of the solution.

The Consumption Projection Model or CPM (formerly known as the Consume model) was initially developed through GLFC CAP funding as a set of linked spreadsheet models for the major predators in the main basin of Lake Huron during the mid- to late- 1990s (Bence and Mehan 1996). With assumed levels of stocking (and/or wild recruitment), natural mortality and fishing effort the model can project fish population abundance-at-age over time. With specified growth, diet and bioenergetics assumptions the model can be used to project consumption of prey fish. Through funding from Michigan DNR these models were moved to a more user-friendly environment programmed in Microsoft Visual Basic®. In this process the models were also modified to assess the effects of changes in size regulations on lake trout. These changes allowed Lake Huron Technical Committee (LHTC) members and fishery managers a wider range of potential uses for the model. For example, the model can readily be used to evaluate how potential changes in lake trout stocking (e.g., pulse stocking), or changes in size limits for recreational harvest of lake trout, or changes in sea lamprey-induced mortality on lake trout (e.g., from treatment of the St. Marys River) are likely to impact both future fishery harvest and prey consumption.

There were, however, several impediments that prevented the full realization of the potential of the CPM. First, the model was developed for the main basin, and without the North Channel and Georgian Bay populations, many Ontario management concerns could not be addressed. Second, although the CPM projected population abundance, an important input for sea lamprey-host models, it did not contain two key prey species (lake whitefish and suckers). If these two prey species were added, the CPM could function as the prototype for the host part of a sea lamprey damage model. Last, ongoing support for the CPM software and databases was missing. Without such support, the numerous databases and parameters would quickly become outdated, reducing the effectiveness of the model. During this project we addressed many of the shortcomings of the first version of the CPM. These enhancements and revisions are described below.

Database updates

Based on data provided by Lloyd Mohr, Ontario Ministry of Natural Resources, new population databases were built for lake trout and Chinook salmon in the North Channel and Georgian Bay (Figure 1). Seven lake trout populations were added corresponding to lake trout management areas LGB1, LGB2, LGB3, LGB4, LNC1, LNC2, and LNC3 (Table 1). Two Chinook salmon databases were created, one for the North Channel and one for Georgian Bay (Table 2). While the majority of data needed to populate the databases was provided by OMNR, some important data tables were missing. Values for these tables were borrowed from similar main basin populations. Missing values for Georgian Bay populations were borrowed from main basin lake trout in MH2 and from lake trout in MH1 for the North Channel populations. The main basin Chinook salmon database provided the missing values for both new Chinook salmon databases. Consumption estimates and projections for the next five years are shown in Figures 2 and 3.

Several lake whitefish populations in the main basin were created as CPM databases. We made use of existing lake whitefish assessment models used for the 1836 treaty waters. Databases for lake whitefish populations cover WFH-01, WFH-02, WFH-03, WFH-04, and WFH-05 (Figure 1). These models did not contain important data used by the CPM to estimate consumption. Lacking gross conversion efficiency (GCE) data for Lake Huron whitefish, we set a default value of 0.20 for all ages, and the diet composition was set to 100% “other”. Abundance estimates and projections for the next five years are shown in Figure 4.

Obtaining the required data for suckers in the main basin was problematic. Their populations have been identified to the CPM control database but associated population databases have not been built. Import templates are available to simplify the process of building these databases when sucker data become available.

New data on the walleye population in Saginaw Bay recently became available. The associated CPM database has been updated with data from Dave Fielder, Michigan Department of Natural Resources, including revised data on numbers stocked, mortality, weight-at-age, and diet composition (Figure 5).

Diet Composition Issues

Diet composition was one of several key inputs in the bioenergetics modeling used to estimate GCEs employed in the CPM. To capture long-term effects rather than impacts of annual variation, mean diet compositions were used for all predator species. The CPM uses these GCEs and the diet composition used to create them to estimate consumption.

We lacked GCE data for lake trout and Chinook salmon in Georgian Bay and the North Channel. We borrowed GCEs from similar main basin populations (Tables 1 and 2) since key data needed for bioenergetics modeling were not available for Georgian Bay and the North Channel. However, the diet composition for the lake trout and Chinook salmon populations in these Ontario waters were significantly different from diets of the same species in the main basin. There is some concern whether the borrowed GCEs are appropriate given the dramatically different diets. To this end, additional bioenergetics models were run on the main basin species to determine the change in the GCE and consumption estimates under varying diet compositions. Only diet composition was varied; other bioenergetics data for the main basin was not changed. The proportion of alewife and rainbow smelt were varied to simulate large diet shifts. The results show that estimates of GCE and consumption can vary by 5-10% (Figure 6). The CPM software does not adjust its estimates when diet compositions vary from those originally used to determine the GCEs. All users of the CPM should be aware that large changes to the diet compositions could cause consumption estimates to vary.

User Training and Ongoing Support

During 2002, there were two training sessions on the CPM software conducted for the LHTC personnel. The first session in January provided a complete overview of the model and the software but only demonstrated the capabilities of the CPM. The second training session conducted in July provided hands-on training.

Overall coordination of the CPM databases and software will now be handled by Ji He (Michigan Department of Natural Resources). His new role was discussed during the January 2004 LHTC meeting. He will be the new contact for questions and issues regarding the model. OMNR has agreed to send Ji He their annual updates to the NC and GB populations so the associated databases can be updated.

The International Laboratory for Great Lakes Fisheries Assessment and Dynamics, located at Michigan State University, will provide server space to house the CPM software and provide download capabilities. Interested parties should contact the chair of the Lake Huron Technical Committee for access to the CPM software and associated databases.

A new software manual is provided with this version of the CPM software. Its 75 pages describe the model’s calculations and assumption, software installation procedures, using the CPM software, methods of importing and exporting data, and error handling processes. It is also available online to all interested parties in a pdf format at http://www.fw.msu.edu/people/bence/pubs/CPM_V2.0_Users_Manual.pdf.

References

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Benjamin, D.M. and J.R. Bence. In press. Statistical catch-at-age assessment of Chinook salmon in Lake Michigan, 1985-1996. Michigan Department of Natural Resources, Fisheries Division, Fisheries Research Report.

Holey, M. E., R. F. Elliott, S. V. Marcquenski, J.G. Hnath, and K. D. Smith. 1998. Chinook salmon epizootics in Lake Michigan: possible contributing factors and management implications. J. Aquat. Anim. Health 10: 202-210.

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Rand P.S. and D.J. Stewart. 1998. Prey fish exploitation, salmonine production, and pelagic food web efficiency in Lake Ontario. Can. J. Fish. Aquat. Sci. 55:318-327.

Stewart, D. J. and M. Ibarra. 1991. Predation and production by salmonine fishes in Lake Michigan, 1978-88. Canadian Journal of Fisheries and Aquatic Sciences 48: 909-922.

Table 1. Summary of database information used for Georgian Bay and the North Channel lake trout populations.

<table>
<tr><th>Item</th><th>Assumptions / Settings during projection</th></tr>
<tr><td>Natural mortality rates</td><td>Constant; borrowed from main basin</td></tr>
<tr><td>Fishing mortality</td><td>Recreational and commercial fishing mortality from OMNR data</td></tr>
<tr><td>Sea lamprey-induced mortality</td><td>Borrowed from main basin</td></tr>
<tr><td>Weight-at-age</td><td>Smoothed weight from von Bertalanffy curve generated from data provided by OMNR; Constant over time;</td></tr>
<tr><td>Diet composition</td><td>Diet data was provided by OMNR. This data was not age specific so the same value is used for each lake trout age. Also, prey weights were not available so diet composition is based on prey count not prey weight.

For Georgian Bay, the mean of 1987-1990 data was used and diet composition is as follows:

<table>
<tr><th>alewife</th><th>bloater</th><th>smelt</th><th>sculpin</th><th>stickleback</th><th>other</th></tr>
<tr><td>0.034</td><td>0.007</td><td>0.592</td><td>0.001</td><td>0.004</td><td>0.362</td></tr>
</table>

Only one year (1987) of data was available for the North Channel and may not reflect actual diets.

<table>
<tr><th>alewife</th><th>bloater</th><th>smelt</th><th>sculpin</th><th>stickleback</th><th>other</th></tr>
<tr><td>0.250</td><td>0.000</td><td>0.750</td><td>0.000</td><td>0.000</td><td>0.000</td></tr>
</table>
</td></tr>
<tr><td>GCE</td><td>GCE data was not available. Georgian Bay(GB) data was borrowed from lake trout in the main basin in MH2 while values for the North Channel(NC) were borrowed from lake trout in MH1.
<table>
<tr><th>Age</th><th>GB</th><th>NC</th></tr>
<tr><td>1</td><td>0.1554</td><td>0.21536</td></tr>
<tr><td>2</td><td>0.1755</td><td>0.19489</td></tr>
<tr><td>3</td><td>0.1413</td><td>0.14818</td></tr>
<tr><td>4</td><td>0.1163</td><td>0.11754</td></tr>
<tr><td>5</td><td>0.1029</td><td>0.10458</td></tr>
<tr><td>6</td><td>0.0997</td><td>0.10848</td></tr>
<tr><td>7</td><td>0.0889</td><td>0.09159</td></tr>
<tr><td>8</td><td>0.0785</td><td>0.08096</td></tr>
<tr><td>9</td><td>0.0706</td><td>0.07245</td></tr>
<tr><td>10</td><td>0.0644</td><td>0.06572</td></tr>
<tr><td>11</td><td>0.0596</td><td>0.06044</td></tr>
<tr><td>12</td><td>0.0557</td><td>0.05634</td></tr>
<tr><td>13</td><td>0.0520</td><td>0.05317</td></tr>
<tr><td>14</td><td>0.0491</td><td>0.05073</td></tr>
<tr><td>15</td><td>0.0515</td><td>0.04236</td></tr>
</table>
</td></tr>
<tr><td>Stocking</td><td>Provided by OMNR</td></tr>
<tr><td>Movement matrix</td><td>Not implemented</td></tr>
<tr><td>Size regulations for lake trout</td><td>Not implemented because Ontario regulations change during the season and the CPM does not provide this option</td></tr>
<tr><td>Natural recruitment</td><td>Assumed to be zero</td></tr>
</table>

Table 2. Summary of database information used for Georgian Bay and the North Channel Chinook salmon populations.

Item	Assumptions / Settings during projection
Natural mortality rates	Constant; borrowed from main basin
Fishing mortality	Recreational and commercial fishing mortality from OMNR data
Sea lamprey-induced mortality	Not implemented
Weight-at-age	Smoothed weight from von Bertalanffy curve generated from data provided by OMNR; Constant over time;
Diet composition	Diet data was provided by OMNR. This data was not age specific so the same value is used for each Chinook salmon age. Also, prey weights were not available so diet composition is based on prey count not prey weight. Diet composition for both Georgian Bay and North Channel populations is as follows: alewife bloater smelt sculpin stickleback other 0.000 0.000 0.584 0.000 0.000 0.416
GCE	GCE data was not available. GCE data was borrowed from the Chinook salmon population in the main basin. Age GCE 0 0.31598 1 0.25417 2 0.17053 3 0.07903 4 0.06629 5 0.06629
Stocking	Provided by OMNR
Movement matrix	Not implemented
Size regulations for lake trout	Not implemented because Ontario regulations change during the season and the CPM does not provide this option
Natural recruitment	Assumed to be zero

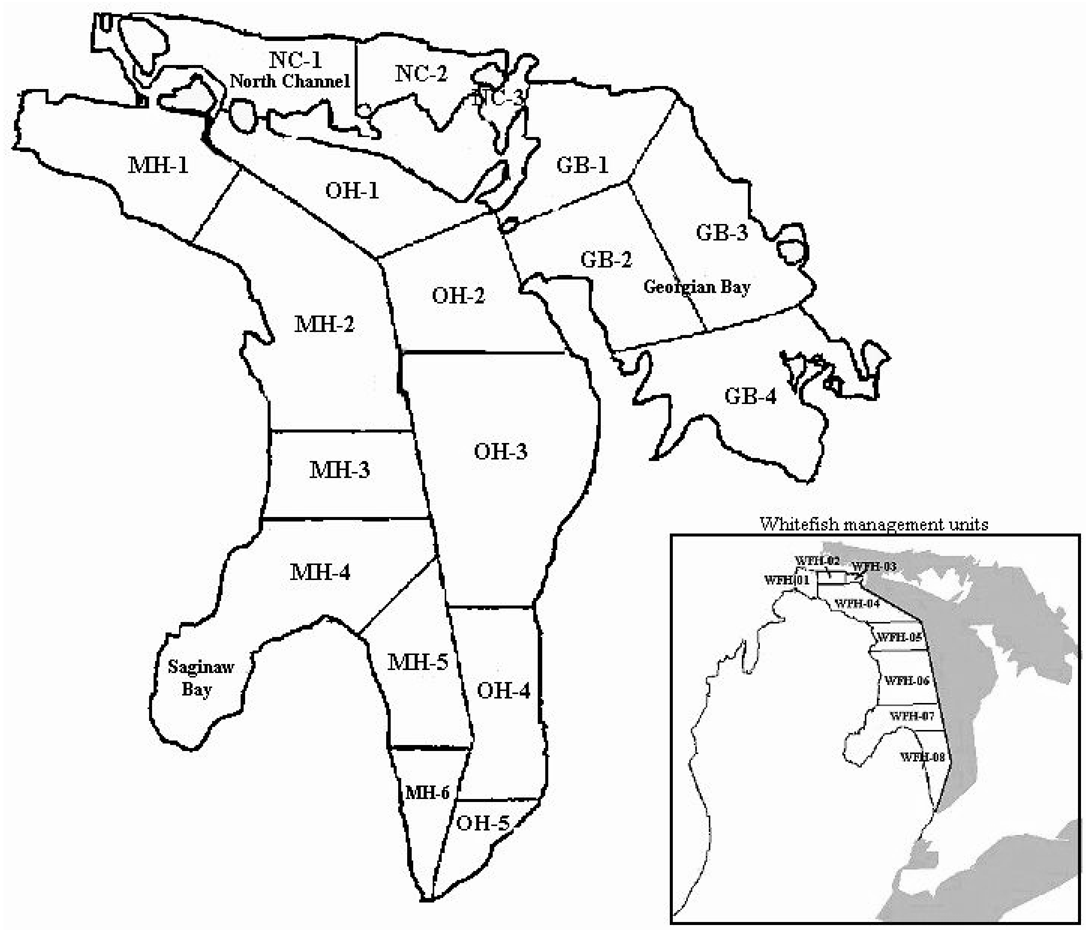


Figure 1. Lake Huron lake trout statistical districts and lake whitefish management units.

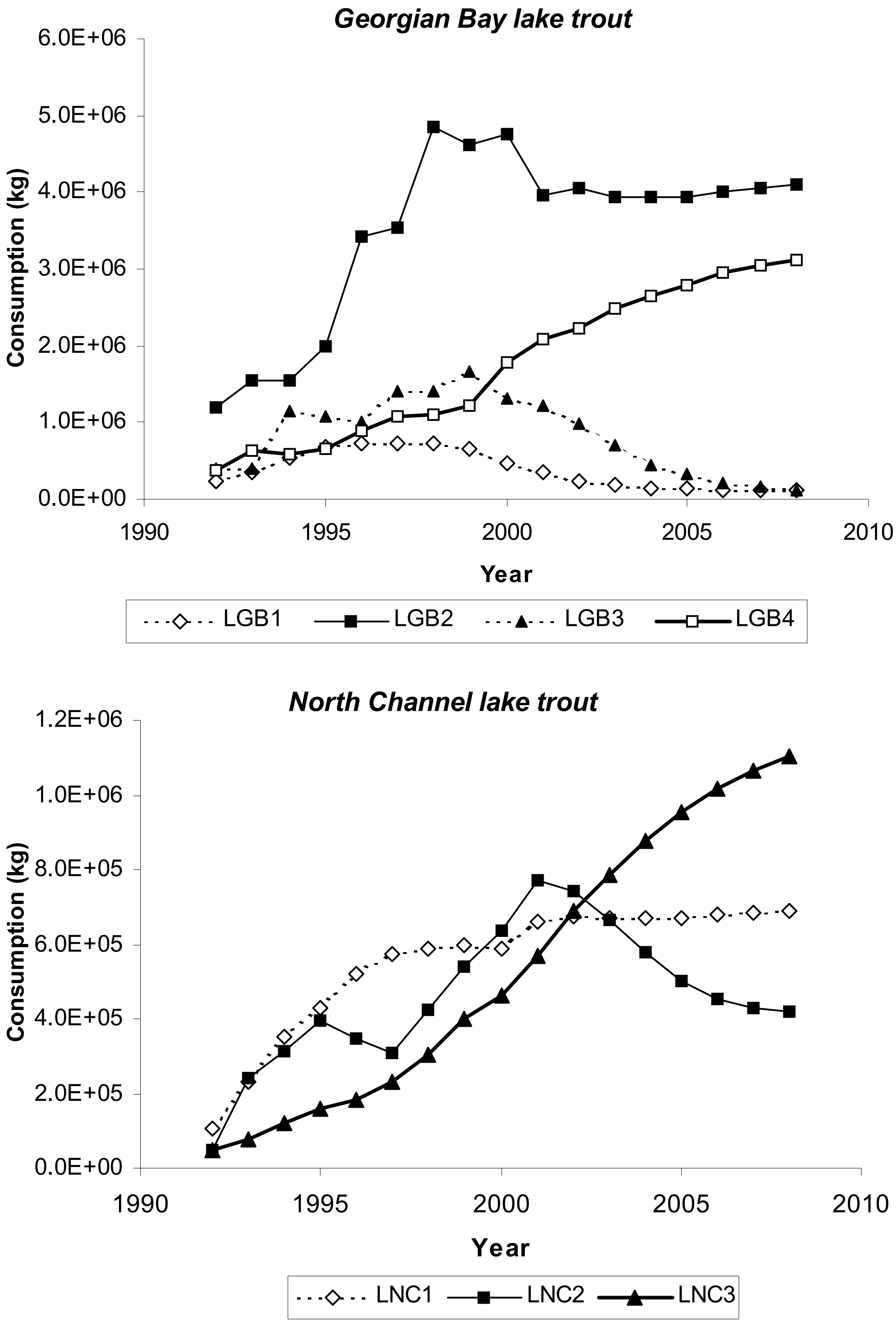


Figure 2. CPM estimates of consumption by lake trout populations in Georgian Bay and the North Channel.

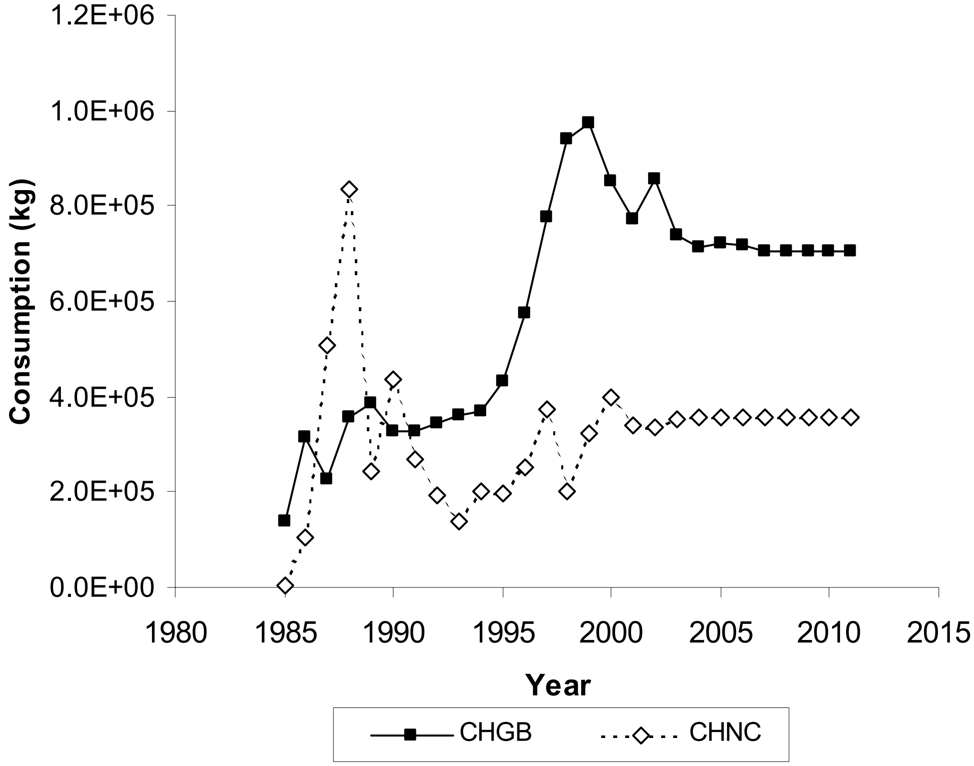


Figure 3. CPM estimates of consumption by Chinook salmon populations in Georgian Bay and the North Channel.

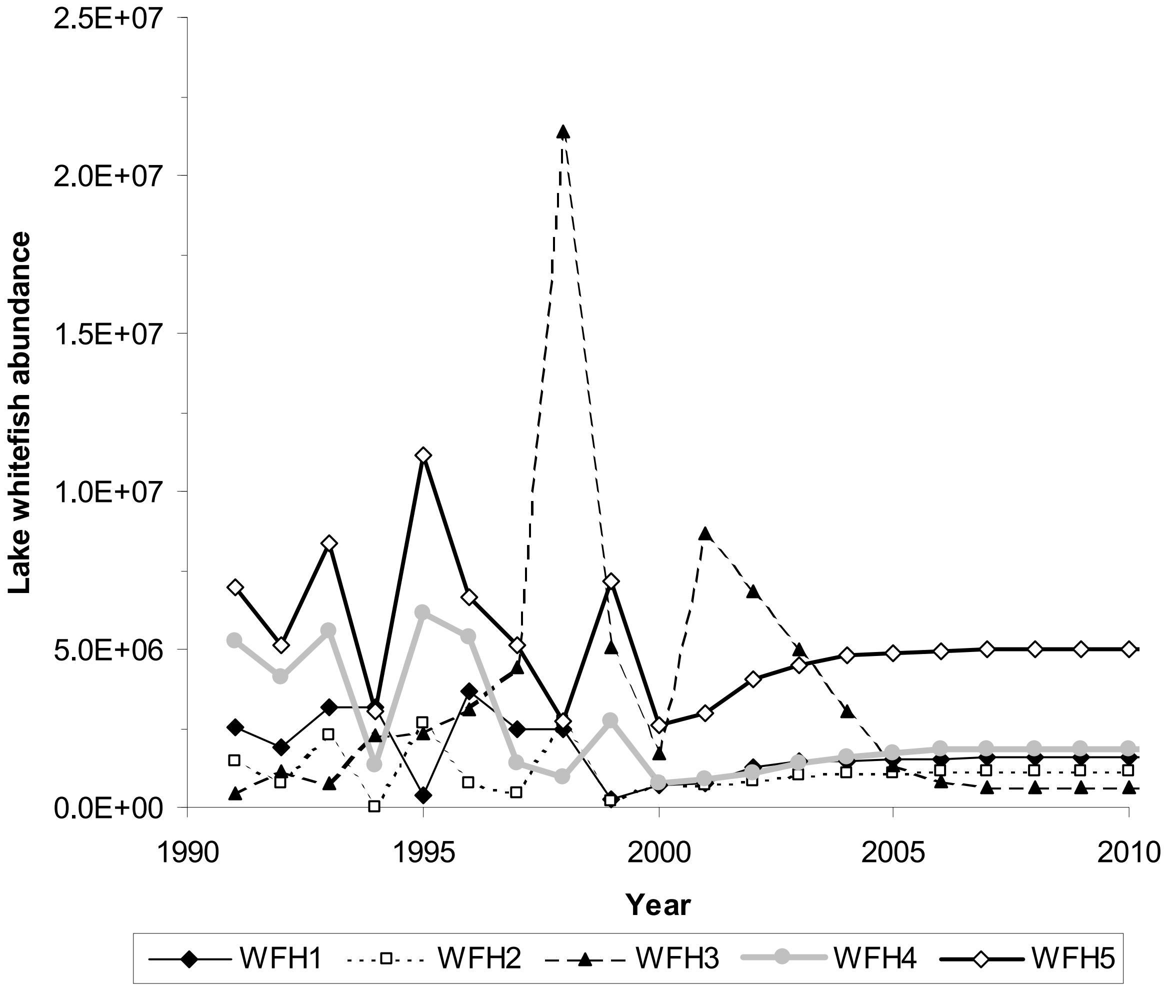


Figure 4. CPM estimates of abundance of lake whitefish populations in the main basin of Lake Huron.

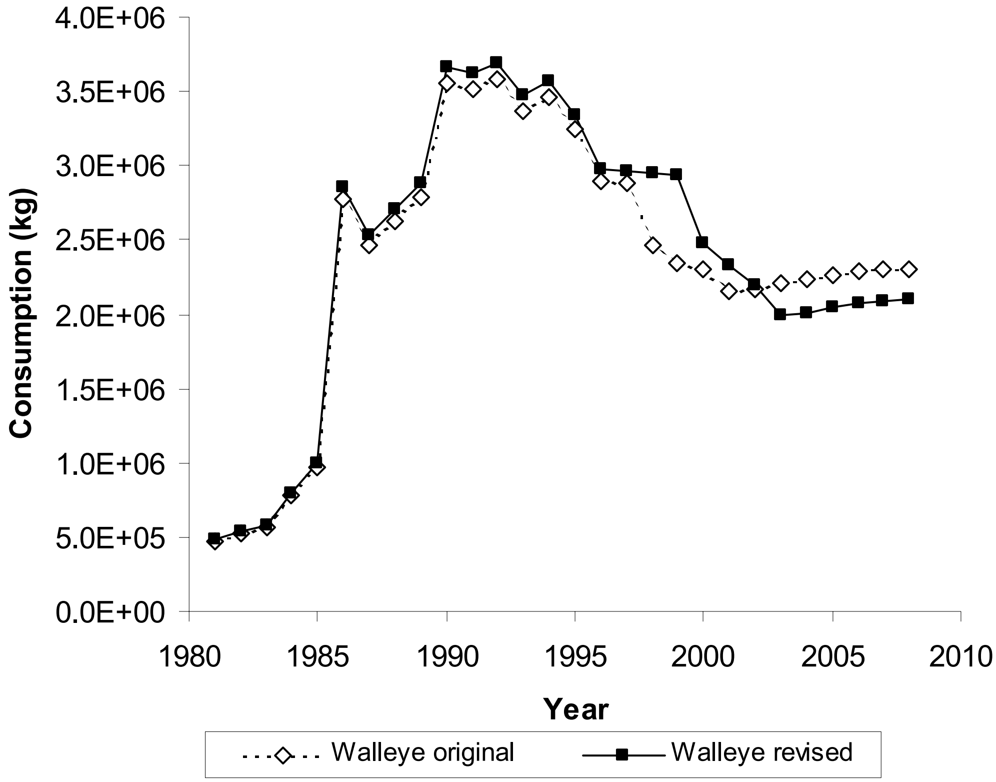
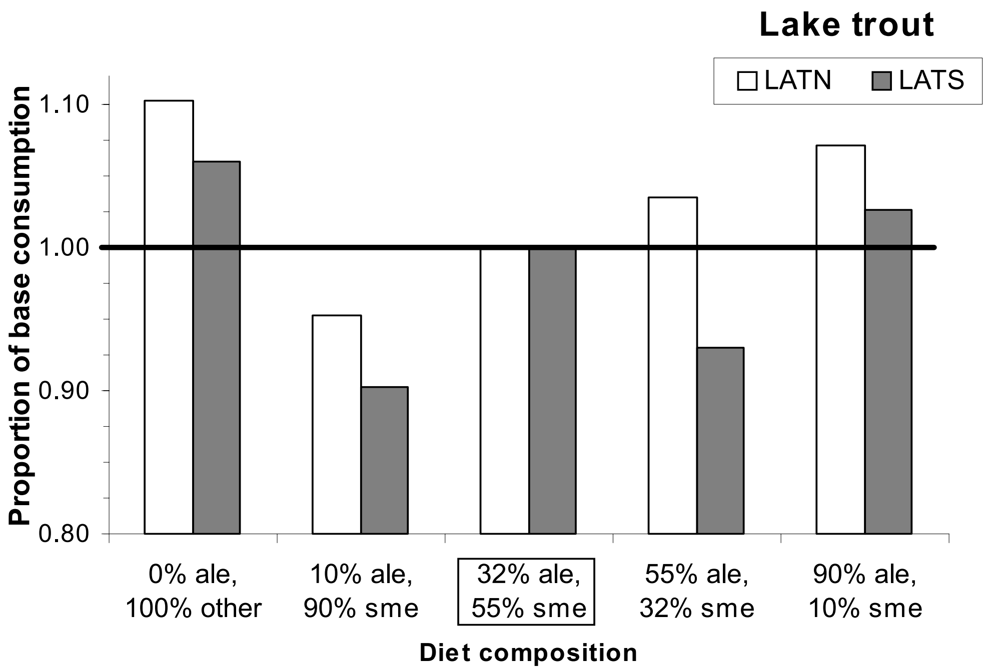


Figure 5. CPM estimates of prey fish consumption by Saginaw Bay walleye showing the results using the original data and the revised data.



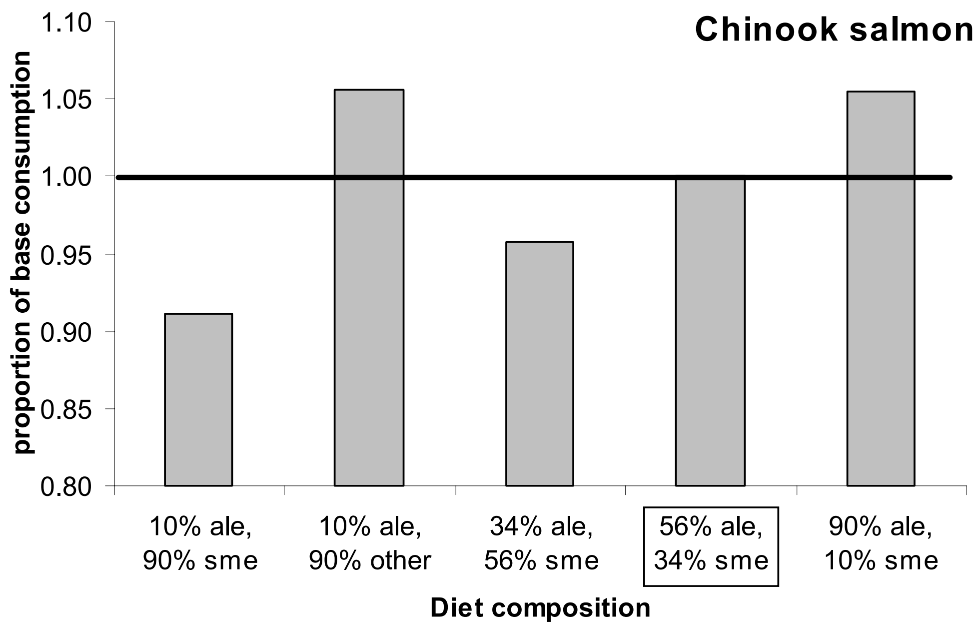


Figure 6. Effects on the CPM consumption estimates using main basin GCEs and varying diet compositions. The diet composition used to determine the GCEs is denoted with a box around the composition. Diets are summarized here as being composed of alewife (ale), rainbow smelt (sme), and other prey fish (other). Bars represent the proportion of the original consumption estimate (base consumption) that could be expected under varying diet compositions.