SEA LAMPREY TROPHIC ECOLOGY IN LAKE SUPERIOR:

RESULTS FROM STABLE ISOTOPE ANALYSIS

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EXTENDED ABSTRACT ONLY - DO NOT CITE

The exotic sea lamprey (*Petromyzon marinus*) contributed greatly to collapses of fish populations in the Laurentian Great Lakes in the mid 1900s (Christie 1974). Despite stringent population control actions in the 1950s and 1960s, sea lamprey persist and continue to affect populations of host fishes. The relative importance of different host species to sea lamprey production is unknown. Therefore, we used stable isotope analysis to ask whether sea lamprey in Lake Superior derive most of their production from lake trout (*Salvelinus namaycush*), as is often assumed, or from alternative hosts. The stable isotope ratio of nitrogen ($\delta^{15}N$) in a consumer's tissues indicates its trophic level, whereas carbon ($\delta^{13}C$) indicates its base of production (Harvey et al., 2002).

We collected transforming, parasitic, and spawning Lake Superior sea lamprey. Transformers and parasites came from eastern U.S. waters. Spawners as well as four potential hosts (lake herring, *Coregonus artedii*; bloater, *C. hoyi*; lean lake trout; siscowet lake trout) were captured throughout U.S. waters. We measured

$\delta^{15}N$ and $\delta^{13}C$ in sea lamprey muscle and host blood. We then compared empirical $\delta^{15}N$ of sea lamprey in eastern Lake Superior to values predicted by a model, developed by Harvey et al. (2002), that estimates stable isotope ratios as functions of growth, based on bioenergetics. Simulations ran one year, during which sea lamprey fed exclusively on one of four hosts (shallow-water coregonines, lean lake trout, siscowet lake trout, or deepwater coregonines).

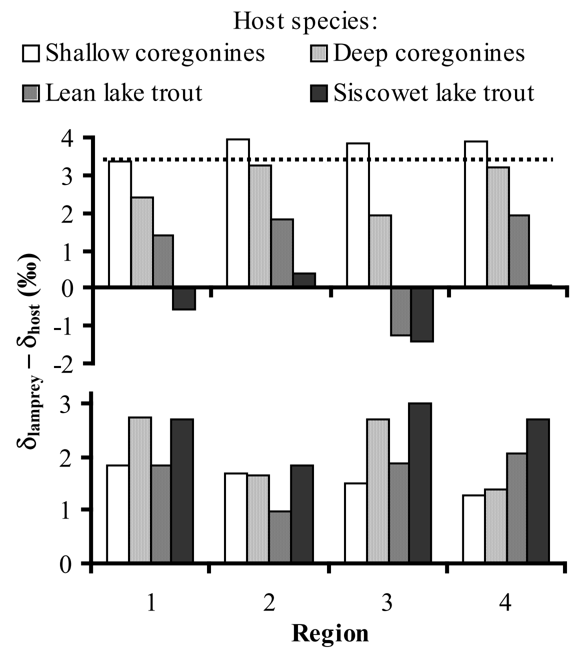

Figure 1. Differences in $\delta^{15}N$ (top) and $\delta^{13}C$ (bottom) between lamprey muscle and host blood. Dashed line in top figure indicates the expected trophic ^{15}N fractionation of + 3.4‰. Regions: 1, Western Lake Superior; 2, Apostle Islands; 3, East of Keweenaw Peninsula; 4, Eastern Michigan.

Relationships between stable isotope ratios of spawning sea lamprey and host fishes varied spatially, and implied sea lamprey diets dominated by coregonines (Fig. 1). Average spawning sea lamprey $\delta^{15}N$ was 3.75‰ greater than lake herring blood at all sites, which is similar to the generally accepted ^{15}N trophic fractionation of 3.4‰ (Harvey et al., 2002). Spawning sea lamprey $\delta^{13}C$ was 1 to 3‰ greater than host blood, the smallest mean difference being with lake herring (1.6‰). Because carbon does not fractionate strongly between consumer and diet (Harvey et al., 2002), this again suggests that coregonines were the main component of sea lamprey diets.

We examined $\delta^{15}N$ and $\delta^{13}C$ from transformers, parasites and spawners in eastern Lake Superior. There was no change in $\delta^{13}C$ as sea lamprey grew (data not shown). However, $\delta^{15}N$ increased from a mean of 1.6‰ for transformers to between 8‰ and 14‰ for parasites and spawners (Fig. 2). This wide range implies that sea lamprey fed on hosts spanning 2 to 3 trophic levels. When empirical data were compared to model projections, empirical $\delta^{15}N$ most closely resembled simulated sea lamprey that fed only on coregonines.

Thus, based on empirical and modeling results, Lake Superior sea lamprey appear most dependent on coregonines, followed by lean lake trout and finally siscowet lake trout. The primary nearshore coregonines upon which sea lamprey feed are probably lake whitefish (*Coregonus clupeaformis*), which are large, abundant, benthic, and isotopically similar to lake herring (Harvey, unpublished data). Many large parasitic sea lamprey exhibited very low $\delta^{15}N$ values (Fig. 2). There are two explanations for this. First, sea lamprey may not fractionate ^{15}N in the same manner as other fishes. Second, sea lamprey may parasitize other hosts that have relatively low $\delta^{15}N$ values. For example, suckers have been shown to have very low $\delta^{15}N$ in other lakes (Kidd et al., 1995).

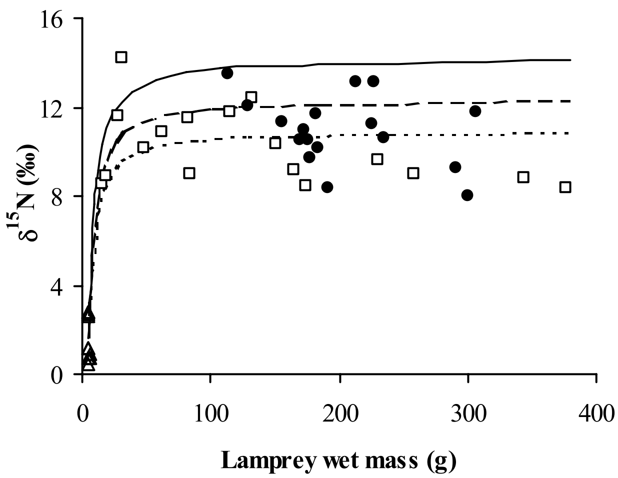

Figure 2. Observed (points) and predicted (lines) $\delta^{15}N$ values of sea lamprey, eastern Lake Superior. Points: △ = transformers; □ = parasites; ● = spawners. Lines: ——— = lamprey that fed on siscowets only; — — — = lamprey that fed on lean lake trout only; - - - - - - = lamprey that fed on coregonines only.

Lake Superior lake trout remain targets of sea lamprey, and sea lamprey-induced lake trout mortality estimates currently resemble or exceed fishing mortality in regions of Lake Superior (Hansen et al., 1994). However, we must recognize that sea lamprey predation occurs in a complex ecological context and affects many species. The techniques described here can yield major advances in our understanding of those dynamics and contribute to estimates of sea lamprey-derived ecological and economic impacts.

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