3: Cumulative Impacts of Many Invasive Species

Zebra mussels

Scientists estimate that about 10 percent of the aquatic species that have been introduced into the Great Lakes have caused significant ecological and economic damage.[55] While the impacts of some of these species are clear, the potential for other direct and indirect impacts remains to be determined. Scientists have, however, concluded that invasive species can affect multiple ecological levels. They influence various functional and behavioral factors for the native species, such as habitat use and foraging, abundance, distribution, food web relationships, and pathways for energy and nutrients.[56] They can alter the physical and chemical conditions of a habitat to an extent that the behavior, growth, and reproduction of native species are impaired. As the Great Lakes are invaded by increasing numbers of exotic species, scientists are discerning some disturbing patterns:

Profound alteration of the base of the food web. Over the past 15 years, invasions in the Great Lakes increasingly consist of tiny invertebrates. While they are important to their native food web, in the Great Lakes they are capable of accumulating in high densities and replacing native ecological equivalents. This dramatically reduces the amount of available nutrient for a number of native species in the system.[57] It also alters the way nutrients and contaminants travel through the food chain and ecosystems of the lakes.[58] (See discussion in next section).

Assault on the ecosystem on multiple fronts. A combination of multiple new species may make life even more

difficult for native species, especially if these invaders are affecting the ecosystem at several different levels.[59] For example, in addition to taking up food energy that would otherwise be in species more readily consumed by forage fish, zebra mussel shells increase the complexity of the lakebed, making it difficult for fish to find food, and thus affecting the way nutrients and energy flow through the food web. The spiny water flea then affects the water column, out-competing native zooplankton. Then the introduced Eurasian ruffe may compete with native species for the limited food resources, further diminishing the survival of natives in the ecosystem.[60]

Facilitation of invasional meltdown (accelerating invasion). Some invaders may alter their new environment in ways that could make it easier for subsequent invasive species to establish themselves, thus accelerating the increase of new species over time.[61] Since 1970 there has been an average of one invader recorded every eight months in the Great Lakes, with the number of species established per decade increasing over time. None of these species have ever successfully been eliminated.[62]

Increased pressures on commercial and sportfish species. As invasive species consume energy, food, and habitat resources, these necessities become less available to the native species that are useful to humans. This may stress sport or commercially valuable species enough that harvest has to be reduced to sustain the population. For example, the Ohio Department of Natural Resources began

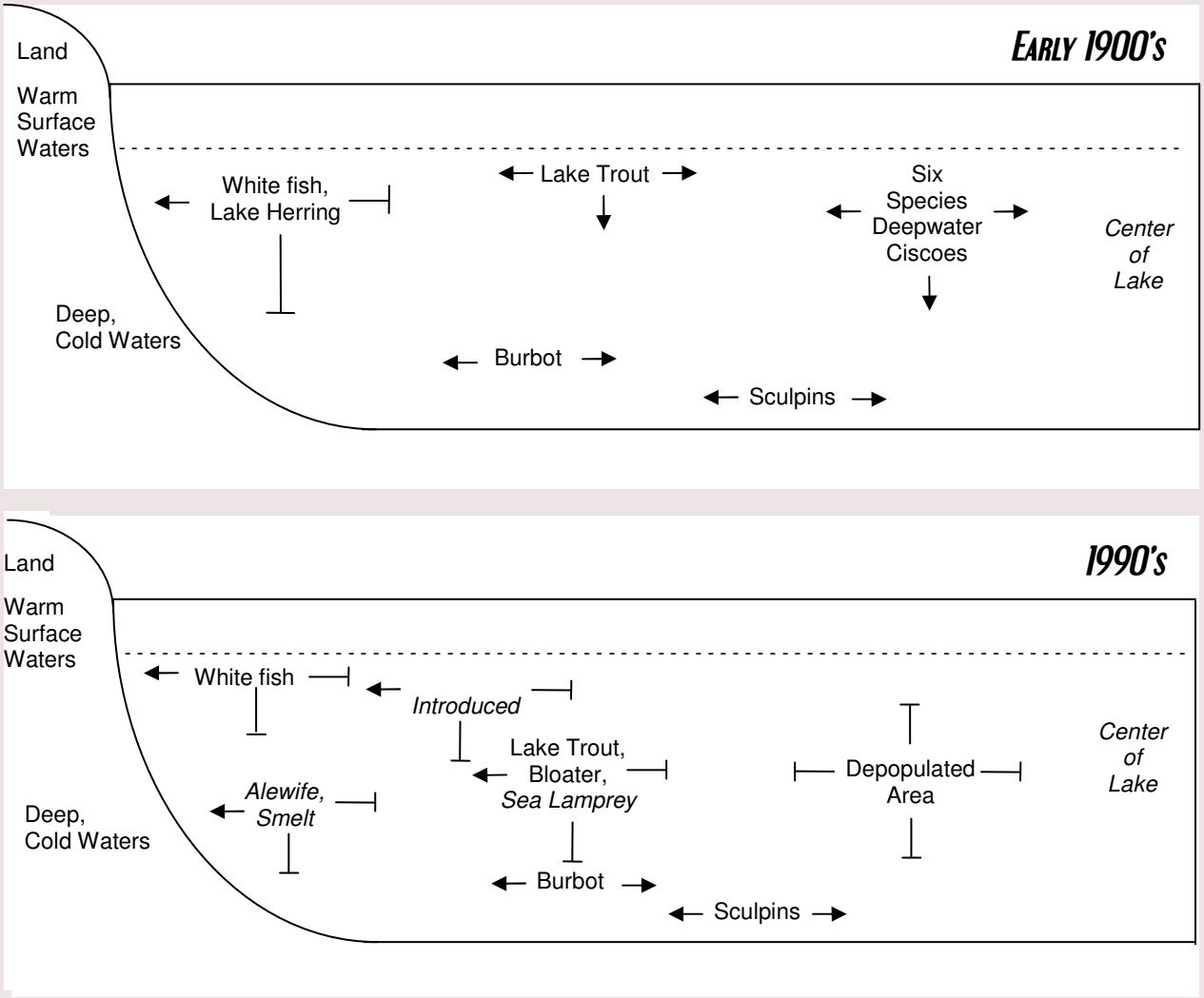

Figure 7: *Changes in generalized distribution of offshore Great Lakes fishes from the early 1900s to the 1990s (adapted from Eshenroder and Burnham-Curtis, 1999).*

Spiny water fleas coating a fishing line

to prohibit the catching of smallmouth bass in Lake Erie during May and June after a long-term study showed that round gobies decimated the nests by consuming eggs in the absence of the male bass guarding the nest.[63] Additional states are considering similar modification of bag limits for recreational anglers to balance the impacts of aquatic invasive species.

Changes in the broader species distribution of fishes. The combination of extinction and depletion of native fish species and introduction of non-native fish has significantly changed the fish distribution in the Great Lakes over the past century, as indicated in Figure 7. Among the changes:

- Among forage fish, lake herring and deepwater ciscoes have been replaced by smelt and alewife (with the most dramatic changes in Lake Ontario);
- Average lengths among the forage fish have decreased substantially (e.g. Lake Michigan deepwater cisco averaged from 203 to 333 mm (about 8 to 13 inches) in length in 1930, while alewife and smelt averaged 66 and 109 mm (about 2 ½ - 4 ¼ inches), respectively, in 1987);
- Invasive forage fish (smelt and alewives) inhabit much shallower waters than the native fish they have replaced, and bloaters whose numbers have recovered in Lakes Michigan and Huron tend to be in shallower waters than before;
- Introduced salmonids (predator fish such as coho and chinook salmon, and steelhead and brown trout), while within the size range of the historically dominant native fish (the lake trout), are shorter lived species, about five years for the introduced salmonids vs. over 20 years for lake trout;
- The introduction of salmonids has been producing a fish community dominated by piscivorous fish (fish that eat other fish) that inhabit the upper waters of the lakes vs. a community historically dominated by piscivorous fish that fed in deeper waters (lake trout and burbot).[64]

Section 5 includes more detailed discussions on impacts of invasive species on fish populations, as well as trends in commercial fish catches.

Extent of Great Lakes Food Web Disruption

Foundation Species	Fish
Diporeia	Lake Trout
Fingernail clams	Yellow Perch
Zooplankton (3 species)	Whitefish
	Smallmouth Bass
	Lake Herring
	Deepwater Ciscoes
	Slimy Sculpin
	Mottled Sculpin

Impacts have varied significantly between species - from near extirpation throughout a lake (e.g. for lake trout) to local depletions (e.g. mottled sculpin).

Figure 8

Sea lamprey attached to a lake trout

IMPACTS ON INFRASTRUCTURE AND BROADER ECONOMY CAN BE SIGNIFICANT

Invasive species introductions are a consequence of the economic welfare of our nation. Many species introductions, both intentional and unintentional, can be linked to economic activities, such as production, trade, and shipping.[65] The irony is that they are now impacting this economic prosperity.[66] Invasive species in general can affect the economy in a number of ways, including production, price and market effects, trade, food security and nutrition, human health and the environment, and financial costs.[67] Two ways that aquatic invasive species have affected infrastructure and the broader Great Lakes economy are indicated below:

Disrupting water infrastructure. Zebra mussels get inside water intake pipes and facilities, resulting in high costs to remove them. As they establish populations in more and more inland lakes in the Great Lakes basin (generally via private smallcraft transport), they put increasingly more water infrastructures at risk. In fact, University of Notre Dame researchers determined that it would be more cost-effective to spend $324,000 per year on efforts to prevent zebra mussel infestation on each inland lake associated with a power plant rather than pay the high costs of managing the negative impacts of zebra mussels on water withdrawals once populations were established in each lake.[68]

Imposing high unending control costs, if control is even feasible. The invasion of the sea lamprey had by the 1940s devastated populations of whitefish and lake trout and resulted in substantial economic losses to recreational and commercial fisheries.[69] From 1900 until trout population declines were caused by sea lamprey, the annual commercial harvests of lake trout exceeded 4.4, 6.3, and 5.5 million pounds annually for Lakes Superior, Michigan, and Huron respectively.[70] Control efforts were initiated in the 1950s, but by the early 1960s, the catch was only about 300,000 pounds. In 1992, annual sea lamprey control costs and research to reduce its predation were approximated at $10 million annually. Ongoing control efforts have resulted in a 90% reduction of sea lamprey populations in most areas, but now, resources spent on controlling these exotics are not available for other fisheries and resource management purposes. This earlier assessment found that the total value of the lost fishing opportunities plus indirect economic impacts in the Great Lakes could exceed $500 million annually.[71]

Lake trout with sea lamprey wounds