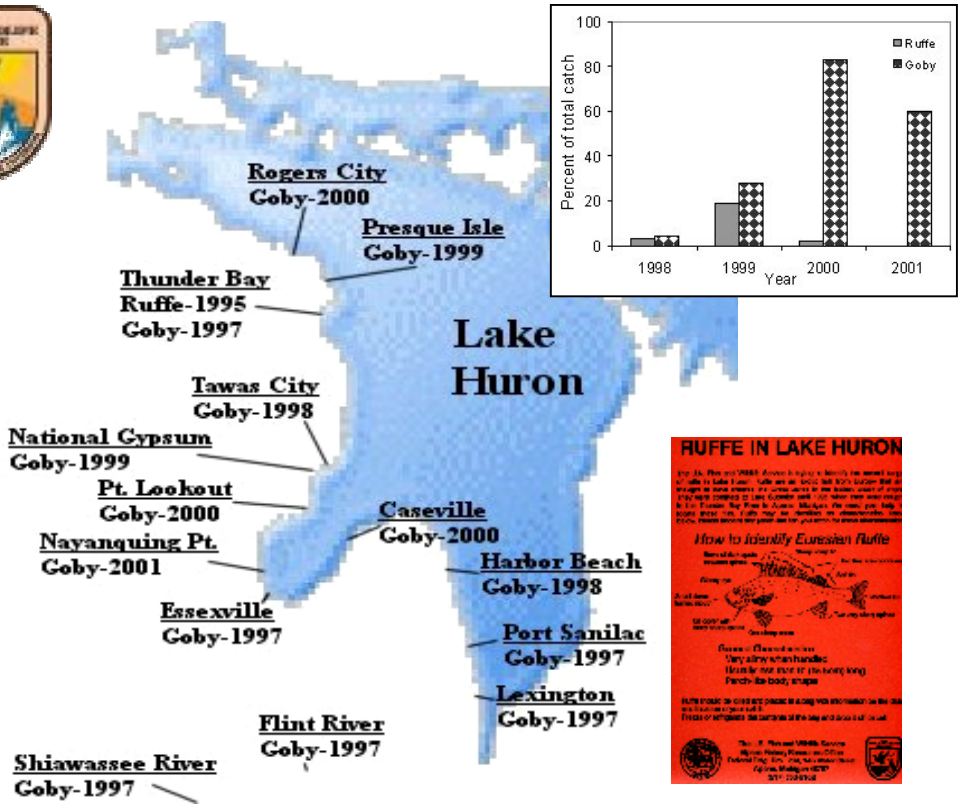
Alpena FRO
Lake Huron Invasive Species Program
2000-2001



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Introduction

The Eurasian ruffe (*Gymnocephalus cernuus*) and round goby (*Neogobius melanostomus*) are two invasive fish species that have expanded their range within the upper Great Lakes. Both are native to Eastern Europe and thought to have been transported to the Great Lakes in the ballast water of ocean-going vessels. They likely have a competitive advantage over native fish for food and habitat because they are frequent spawners, allowing them to become abundant quickly, and they have aggressive natures (Busiahn and McClain 1995, Jude 1997). Both Eurasian ruffe (ruffe) and round goby (goby) have been found in Lake Huron; and although the known range of ruffe continues to be confined to one location (Thunder Bay) (Czypinski et al. 2000), the range of round goby has spread to many areas in the lake (Figure 1). The U. S. Fish and Wildlife Service (Service) Fishery Resources Office in Alpena, Michigan (Alpena FRO) has been actively involved in surveying for new populations of these invasives, monitoring the current status of established populations and their affect on native fish communities in Lake Huron, and educating the public about what they can do to prevent their spread.

Figure 1. Sighting locations of invasive ruffe and round goby in U. S. waters of Lake Huron.

Background

Initial efforts to survey for invasives in the Great Lakes began with the accidental introduction and subsequent proliferation of ruffe in western Lake Superior. Ruffe were first discovered in the St. Louis River mouth in Duluth, Minnesota in 1986 (Pratt et al. 1992) and by 1991 they had become the most abundant fish captured in bottom trawling surveys in the area (Bronte et al. 1998; Busiahn and McClain 1995). The increase of ruffe may have negatively impacted some native forage species, including yellow perch (*Perca flavescens*), which showed declines in relative abundance over the same time period (Bronte et al. 1998). The Great Lakes Fishery Commission designated a special task force to evaluate the problem (Ruffe Task Force 1992) and by 1992 ruffe were designated an aquatic nuisance species.

A ruffe control plan was developed with the goal of "*preventing or delaying the further spread of ruffe through the Great Lakes and preventing their spread to inland lakes and watersheds*" (Ruffe Control Committee 1996; Busiahn and McClain 1995). Objectives of the control program are to 1) minimize the transport of ruffe from western Lake Superior through ballast water management, and support the development of technologies to prevent transport, 2) continue and expand investigations of ruffe populations to evaluate the impact on affected fish communities and to provide information necessary to plan, implement, and evaluate control activities, 3) eliminate or reduce reproducing populations, using appropriate technologies, where feasible, 4) conduct surveillance sampling in likely locations to find newly established populations of ruffe, and designate a single office to compile collections of ruffe, 5) recommend fish management practices that will improve resilience of fish communities against invasion or dominance of ruffe, 6) develop and promote information and education programs to identify ruffe so that they will not be transported alive and so that they will be killed and reported if taken, 7) assist jurisdictions in developing model language for regulation of bait harvest and possession, and 8) consider options to prevent the movement of ruffe from the Great Lakes to the Mississippi watershed via the Chicago, Des Plaines, and Illinois Rivers (Ruffe Control Committee 1996; Busiahn and McClain 1995). Since 1995, and following the discovery of ruffe in the Thunder Bay River in Alpena, Michigan, the Alpena FRO has actively participated in each aspect of the program to cover U. S. waters of Lake Huron.

In 1997, following the rapid spread of the goby, the Alpena FRO shifted efforts from a program centered on ruffe to one centered on invasive fish species in Lake Huron. The goby was first discovered from Lake St. Clair in 1990 (Jude et al. 1992) and immediately began to extend their range to new locations. It is believed that goby range expansion within the Great Lakes was facilitated through transport in the ballast water of commercial freighters (Pratt et al. 1992). Goby were being found in areas around Lake Huron and Alpena FRO began to monitor their spread and affects on native fish species beginning in 1998.

In order to monitor, manage, and control invasives in Lake Huron, the Alpena FRO has collaborated with other agencies and organizations to address the following issues: monitoring the status and trends of co-existing invasive and native fish populations, conducting surveillance to detect newly established invasive populations, evaluating fish use of invasive populations as a diet item, managing ballast water and regulating bait harvest to minimize invasive transport, preventing the movement of Great Lakes invasives into the Mississippi watershed, and developing education programs to assist in angler identification and reporting of invasives.

Status and trends of co-existing invasive and native fish populations

Information on the status and trends of invasive and native fish populations in Lake Huron has been gathered through index fall bottom trawling, 1996 to 2001. Invasives have been detected at three ports, including Thunder Bay, National Gypsum, and the Saginaw River. In other areas of the Great Lakes, increases in the abundance of invasives have negatively corresponded with native populations (Bronte et al. 1998), likely due to the aggressive nature of invasives and competition for food and habitat (Jude 1997). Ruffe and goby particularly pose problems in infested areas because they are able to spawn multiple times in a season and increase in abundance quickly – magnifying their negative effects (Busiahn and McClain 1995, Jude 1997).

A semi-balloon bottom trawl (4. 9 m trawl, 2.5 cm mesh body with 6.4 mm mesh cod) was used to conduct surveys at index locations. Approximately 30 minutes of effort was concentrated in the deepest and most turbid parts of the channel, which is preferred ruffe habitat (Busiahn and McClain 1995). Surveys were conducted in September and October corresponding to times when ruffe were most commonly encountered. Beginning and ending water depth (m) and GPS coordinates were recorded for each tow, and bottom and surface water temperature (°C) were recorded at each survey location. Fish were sorted by species, counted, and lengths recorded on 15 random fish from each species. All fish except ruffe and goby were returned to the water following data collection. Ruffe and goby scale samples were removed, pressed, and viewed from a sub-sample of up to 10 fish per centimeter length group to estimate age. The relative abundance of each species in catch per effort (CPE) and the species as a percentage of the total catch was determined for each location and comparisons made. The invasive and native fish communities of Thunder Bay, National Gypsum, and the Saginaw River have been examined and a report on their status and trends follows.

Thunder Bay-Eurasian ruffe & round goby

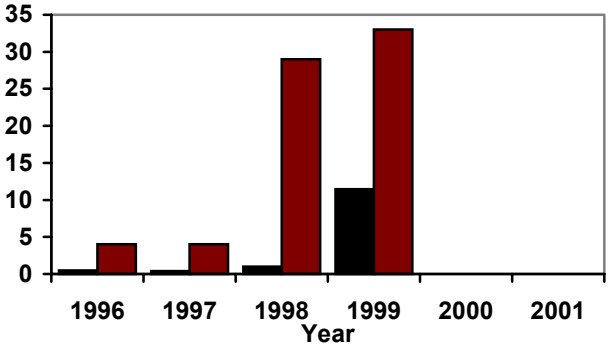

Figure 2. Ruffe relative abundance [catch per minute (dark) and percent of total catch (gray)] in the Thunder Bay River from 1996 to 2001.

The Thunder Bay River is located in northeastern Michigan and empties into Thunder Bay, Lake Huron in Alpena, Michigan. The river stretches 1.8 km upstream to the first dam, which prevents the unassisted spread of invasives to upper reaches. The mouth to 1.4 km upstream is dredged to an average depth of 7 m to allow commercial freighter passage to deliver salt and coal, which are used by local industries and county municipalities. Tannins color the water brown and sediments are sand and silt with woody debris.

Thunder Bay is a shallow clear water bay that covers 163 km^2 and ranges in depth from 8 to 18 m. A substantial amount of freighter traffic enters the bay to come to port at the Lafarge Cement Corporation in Alpena, located just 1.5 km north of the Thunder Bay River. Both ruffe and round goby have been captured from the Thunder Bay River and Thunder Bay, likely due to assisted transport in the ballast water of freight traffic. In 1996, following the discovery of ruffe in the Thunder Bay River, the Lake Carriers' Association imposed a voluntary ballast exchange for ships that take on ballast in Thunder Bay (Harkins 1996).

These measures were imposed to minimize the risk of ruffe and other invasive transport out of the Alpena harbor.

Ruffe were first captured from the Thunder Bay River in 1995 during bottom trawling efforts to detect their spread in the Great Lakes (Kindt et al. 1996). Until that time, ruffe were only known to be present in western Lake Superior. Within the Thunder Bay area, their presence has been limited to a relatively confined location encompassing the Thunder Bay River mouth (upstream 1.8 km to the dam), the river shipping channel from the river mouth to the first marker buoy (0.6 km), and one incidence at the Lafarge Cement port. The majority of ruffe have been captured from the Thunder Bay River.

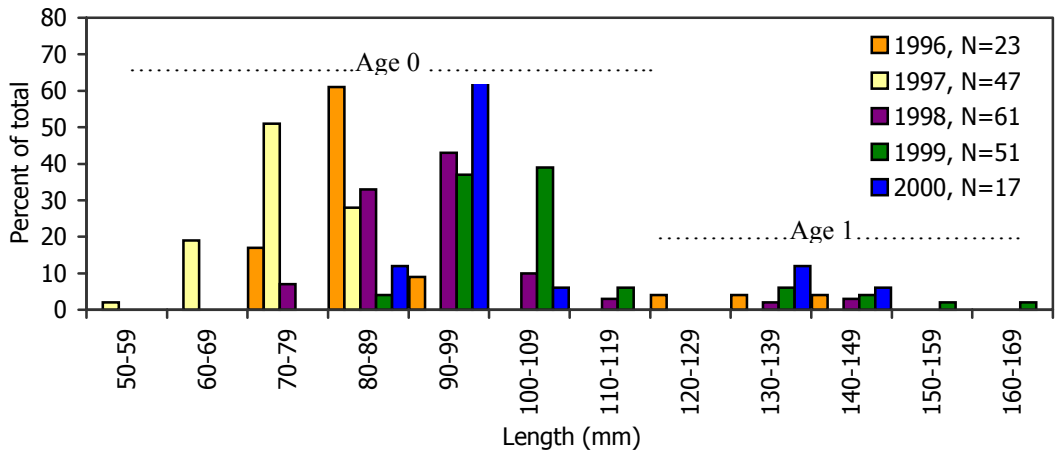

Figure 3. Length and age distribution of ruffe captured from the Thunder Bay area from 1996 to 2001.

The relative abundance of ruffe increased steadily in the Thunder Bay River from 1997 through 1999 (Figure 2). In 1998 and 1999, ruffe were the most abundant species captured during fall bottom trawling surveys. The majority of the ruffe captured from 1996 to 1999 were young-of-the-year (YOY) confirming the presence of a reproducing population; however, if ruffe were surviving through the winter the catch of adult ruffe would likely be higher (Figure 3). Adult ruffe comprised a low percentage of the overall catch.

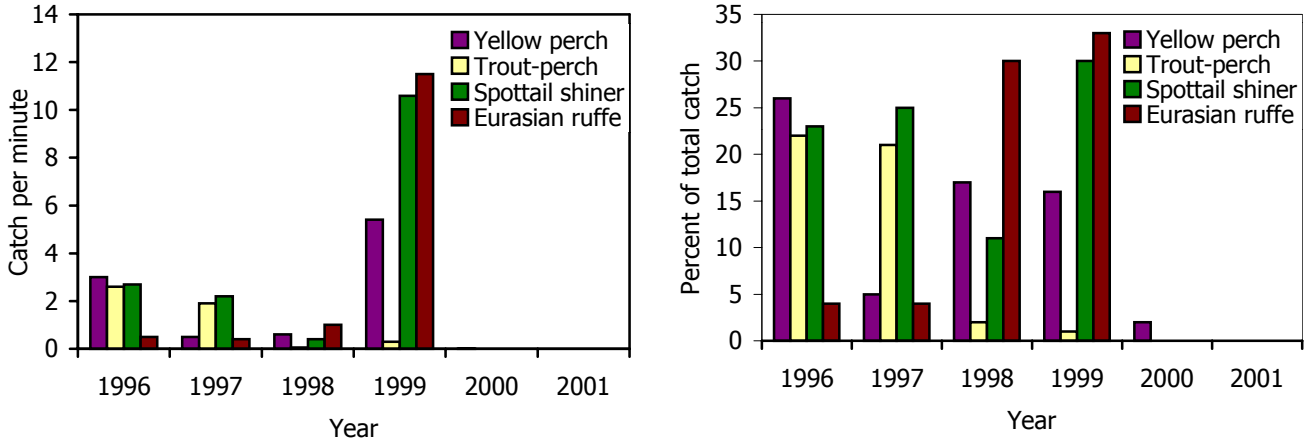

Figure 4. Yellow perch, trout-perch, spottail shiner, and ruffe relative abundance in CPE and % of total catch from 1996 to 2001.

In the St. Louis River estuary, inverse correlations were detected between densities of ruffe and native fish species including yellow perch, spottail shiner (*Notropis hudsonius*), trout-perch (*Percopsis omiscomaycus*), and emerald shiner (*Notropis atherinoides*) from 1989 to 1993 (Bronte et al. 1998). We examined the catch per effort and percent of total catch of yellow perch, trout-perch, and spottail shiner in the Thunder Bay River to detect trends in abundance as they co-exist with ruffe (Figure 4). In 1996 and 1997, relative abundances for all three species were greater than ruffe (Figure 4). By 1998 two of the three species had relative abundances below that of ruffe and by 1999 the relative abundance of each of the three species were below that of ruffe.

There was not an apparent trend in yellow perch or spottail shiner abundance from 1996 to 1999 (Figure 4); and both species remained within the top 5 most abundant species captured. Trout-perch, however, was the within the top 3 most abundant species captured in 1996 and 1997 then their abundance decreased dramatically and remained low; even when the abundances of other species were recovering in 1999 (Figure 4).

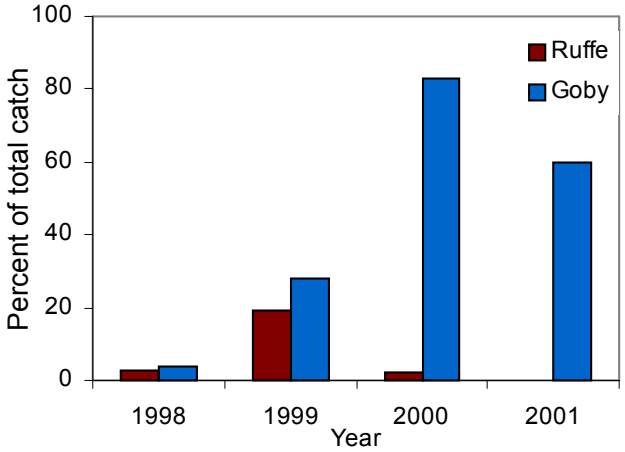

Figure 5. Ruffe and goby relative abundance (% of total catch) in Thunder Bay from 1998 to 2001.

1999 was a particularly favorable year for yellow perch, spottail shiner, and ruffe due to the mild winter of 1998 and the following early warm spring (Figure 4). Surprisingly, no ruffe were captured from the river in 2000 or 2001 despite survey efforts. In 2000 only 17 ruffe were captured from the Thunder Bay area (from Thunder Bay shipping channel) and no ruffe were captured in Thunder Bay or anywhere in Lake Huron in 2001. Yellow perch was the only one of the four species that was captured from the Thunder Bay River in 2000 and none of these species were captured in 2001.

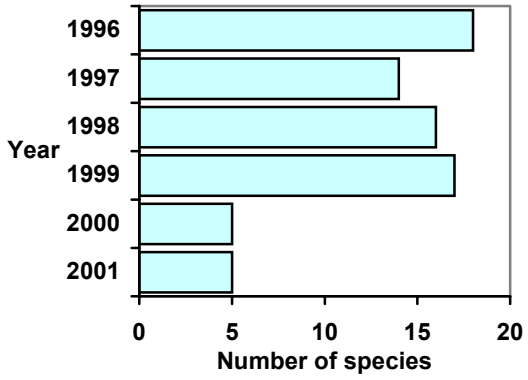

Figure 6. Number of species captured from the Thunder Bay River during fall trawling surveys from 1996 to 2001.

Round goby were first reported and confirmed in Thunder Bay in 1997 by an angler. In 1998 goby were captured during bottom trawling surveys in the bay and were the most abundant species present in the catch (Figure 5). By 1999 goby were discovered in the Thunder Bay River where they represented only 4% of the total catch. Surprisingly, by 2000 goby were the most abundant species captured from the Thunder Bay River (Figure 5) and no ruffe and associated species, including yellow perch or trout-perch, were captured (Figure 4). Due to the aggressive, bottom dwelling, and egg feeding nature of goby (Jude 1997), it is suspected that they may be impacting ruffe and native species that use the Thunder Bay River.

The diet of goby and native bottom dwelling species such as darters, sculpin, Logperch (*Percina caprodes*), and some minnows overlap substantially, and goby have been found to eat fish including trout-perch (Jude 1997). Due to these negative impacts of goby, we attempted to compare the relative abundance of goby with sculpin and darters in the Thunder Bay River prior to and following the goby invasion; however, the abundance of johnny darters (*Etheostoma nigrum*) were low prior to and after goby infestation and sculpin had not been captured from the river. The abundance of trout-perch declined to 0 in years when goby were most abundant (2000 and 2001) (Figure 4). It was also interesting to note that the species diversity of the catch decreased in years when round goby were most abundant (2000 and 2001) (Figure 6).

National Gypsum – round goby

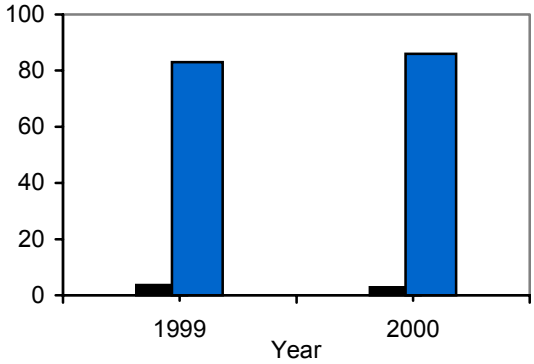

Figure 7. Goby relative abundance [catch per minute (solid) and percent of total catch (cross hatch)] at National Gypsum from 1999 to 2001.

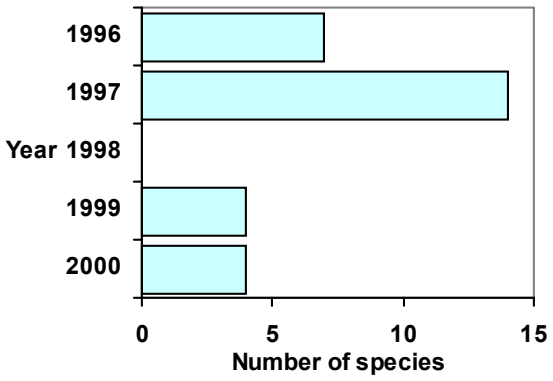

Figure 8. Number of species captured from National Gypsum during fall trawling surveys from 1997 to 2000.

National Gypsum is a port located at the south end of Tawas Bay, Lake Huron near Alabaster, Michigan approximately 3 km south of Tawas, Michigan. The loading dock runs out from the shoreline and a shipping channel is dredged to allow freighter passage to the port. Alpena FRO began monitoring the port for the presence of invasives in 1996. In 1998, anglers in Tawas City first reported goby, and by 1999 they were detected during fall index sampling (Figure 7). Goby were the most abundant species captured in 1999 and 2000. No sampling was conducted in 2001 due to equipment failure.

We examined the abundance of native johnny darters, slimy sculpin (*Cottus cognatus*), and trout-perch as a portion of the total catch in 1996 and 1997, prior to the invasion of goby at National Gypsum, then after from 1999 through 2000. Trout-perch was the most abundant species captured in 1996 and 1997 and were not present in the catch in 1999 or 2000. Johnny darter was the second most abundant species present in 1996 and was present in low abundance in 1997 and 1999 but not in 2000. Slimy sculpin was fourth in abundance in 1996 but absent from catches made in following years. No sampling was conducted in 1998 due to equipment failure. Again we noted a decrease in the number of species present in the catch during years when goby were most abundant (1999 and 2000) (Figure 8).

Saginaw River – round goby

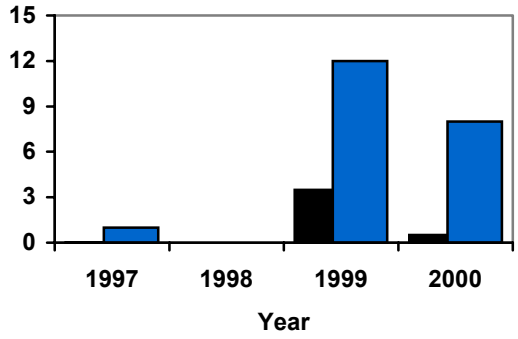

Figure 9. Goby relative abundance [catch per minute (solid) and percent of total catch (cross hatch)] in the Saginaw River from 1997 to 2001.

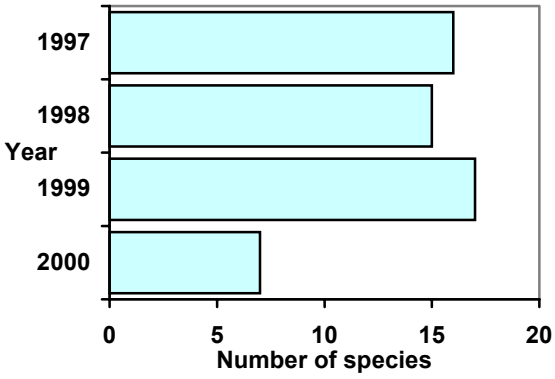

Figure 10. Number of species captured from the Saginaw River during trawling surveys from 1997 to 2000.

The Saginaw River is located in east central Michigan and empties into Saginaw Bay, Lake Huron at Essexville, Michigan. The river provides shipping access to Bay City and Saginaw, Michigan – the highest area of commerce in US waters of Lake Huron. The Saginaw River supports one of the largest amounts of shipping traffic in Lake Huron. Goby were first captured from the Saginaw River mouth in 1997 during initial invasive surveillance trawling (Figure 9). One goby was captured and it was the least represented species; comprising less than 1 percent of the total catch. No goby were captured in 1998; however, similar surveys conducted by the Michigan Department of Natural Resources captured large numbers of goby. In 1999 and 2000, goby were the third most abundant species captured. No sampling was conducted in 2001 due to equipment failure.

Johnny darter were present in the catch in 1998 and 1999, but at such a low abundance that a comparison could not be made. Slimy sculpin were not captured from the Saginaw River. Trout-perch were present in the catch in 1997 through 1999, but at too low of an abundance to make a comparison. We did not see a decrease in the number of species represented in the catch from 1997 to 1999, however there was a decrease in 2000 (Figure 10). It should be noted that goby were not the most abundant species present in the Saginaw River during this time period.

Surveillance to detect newly established invasive populations

Alpena FRO began to conduct invasive surveillance in Lake Huron waters following the initial discovery of ruffe in the Thunder Bay River in 1995 (Kindt et al. 1996). Initial surveillance activities in Lake Huron began in 1992 (Slade and Kindt 1993) and were conducted annually through 1995 by the Ashland FRO. In August 1995, three ruffe were captured from the Thunder Bay River mouth in Alpena, Michigan on northwestern Lake Huron during surveillance efforts (Kindt et al. 1996). This was the first, and only area to date, where ruffe have been found outside of Lake Superior. Alpena FRO immediately began monitoring the fish community in the Thunder Bay River and began to conduct invasive surveillance in Lake Huron beginning in 1996. A semi-balloon bottom trawl (4. 9 m trawl, 2.5 cm mesh body with 6.4 mm mesh cod) is used to conduct invasive surveillance. Sixteen sites in Lake Huron from Sault Ste. Marie to Harbor Beach are surveyed for new invasive populations (Figure 11). All sites are located near shore at shipping ports

or at river mouths where there is regular shipping or boating traffic. The deepest and most turbid parts of the channel, which are preferred ruffe habitat, are sampled (Busiahn and McClain 1995).

Twelve of the index sites are sampled annually and four sites are sampled every two to three years. Sites that are rotated are either difficult to sample or have limited commercial ship traffic. Rotational sampling will continue until ruffe are found outside of Thunder Bay. Those sites that are sampled annually include Sault Ste. Marie, DeTour Passage, Port Dolomite, Cheboygan River, Thunder Bay River, Thunder Bay (River shipping channel), Thunder Bay (Lafarge Corporation), Squaw Bay, Black River, National Gypsum, and the Saginaw River. Those sites that are sampled every two to three years are Calcite, Harrisville Harbor, AuSable River, AuGres River, and Harbor Beach.

Figure 11. Sixteen sites on Lake Huron have been surveyed for invasive fish species. Sites include: 1) Sault Ste. Marie, 2) DeTour Passage, 3) Port Dolomite, 4) Cheboygan River, 5) Calcite, 6) Thunder Bay River, 7) Thunder Bay (Lafarge shipping channel), 8) Thunder Bay (River shipping channel), 9) Squaw Bay, 10) Black River, 11) Harrisville Harbor, 12) AuSable River, 13) National Gypsum, 14) AuGres River, 15) Saginaw River, and 16) Harbor Beach.

The St. Marys River sites (Sault Ste. Marie and DeTour Passage) were added in 2000 to provide coverage for this area of ship passage between Lakes Huron and Superior. In addition to Great Lakes freighters, ocean-going vessels pass into Lake Superior to receive goods from the port in Duluth, Minnesota. The St. Marys River is a confined area and ships frequently adjust ballast water to navigate through the Soo Locks in Sault Ste. Marie.

In 2000 surveillance was conducted at ten locations: Black River, Cheboygan River, DeTour Passage, National Gypsum, Port Dolomite, St. Marys River, Saginaw River, Thunder Bay River, Thunder Bay (Lafarge shipping channel), and Thunder Bay (River shipping channel); and due to equipment failure in 2001, surveillance was limited to six locations: Cheboygan River, Port Dolomite, St. Marys River, Squaw Bay, Thunder Bay River, and Thunder Bay (River shipping channel).

Surveillance was conducted in September and October corresponding to times when ruffe were most commonly encountered. Approximately 30 minutes of effort was concentrated at each sampling location, and consisted of 3 to 6 tows of from 5 to 10 minutes in length. Beginning and ending water depth (m) and GPS coordinates were recorded for each tow, and bottom and surface water temperature (°C), air temperature (°C), and weather conditions were recorded at each survey location.

All fish were sorted by species and counted. Lengths were recorded on 15 random fish from each species, and fish were returned to the water following data collection. Relative abundance in catch per effort (CPE) per species was determined at each location. The percent of the total catch was similarly determined for each species per location. Eurasian ruffe and round goby were not returned to the water. Voucher specimens were preserved in alcohol for each location where the exotics were captured.

Table 1. Characteristics of invasive fish surveillance in Lake Huron, in 2000 and 2001.

Location	Year	Date	Depth (M)	Temp (°C)	Effort (Min.)	# of Species	Total Catch	Most Abundant Species	% of Total Catch	Ruffe	Goby
Port Dolomite	2000	9/5	6.8	18.1	30.0	7	54	Spottail shiner	37		
	2001	9/26	6.2	16.0	7.5	2	7	Slimy sculpin	57		
Cheboygan River	2000	10/4	6.7	14.4	29.5	11	71	Bluntnose minnow	41		
	2001	9/21	6.3	17.8	30.0	9	387	Spottail shiner	70		
LaFarge Shipping Channel	2000	9/28-10/5	6.6	13.9	20.5	1	12	Round goby	100		12
Thunder Bay River	2000	9/25-10/13	5.7	14.3	46.5	5	67	Round goby	91		61
	2001	9/10 & 10/15	4.0	12.4	27.0	5	35	Bluegill	74		4
Thunder Bay Shipping Channel	2000	9/20-9/28	5.9	14.4	64.0	8	952	Round goby	83	17	793
	2001	9/10 & 9/18	5.7	17.7	49.5	12	1011	Round goby	61		619
Squaw Bay	2001	10/18	1.0	15.0	13.0	3	10	Killifish	70		
National Gypsum	2000	9/27	6.4	14.1	30.0	4	100	Round goby	86		86
St. Marys River (Sault Ste. Marie)	2000	9/8	9.1	17.0	25.0	2	2	Logperch & Troutperch	100		
	2001	9/26	6.5	13.8	31.0	2	6	Spottail shiner	83		
St. Marys River (DeTour Passage)	2000	9/6	7.7	17.6	37.0	11	57	Spottail shiner	35		
Saginaw River	2000	9/26	7.1	15.3	30.5	7	169	Freshwater drum	47		14

In 2000 and 2001 a total of 313 and 114 minutes of effort, respectively was concentrated in Lake Huron shipping channels and river mouths to survey for invasive ruffe and goby (Table 1). A total of 1,443 fish from 26 species were captured in 2000 and 1,407 fish from 20 species were captured in 2001. No expansion in the range of ruffe was detected in 2000 or 2001; however ruffe continued to persist in Thunder Bay in 2000 (Table 1). They were present at a much lesser extent in Thunder

Bay in 2000 than in 1999 and were not captured in 2001. The catch per effort of ruffe in the Thunder Bay River decreased by 11 percent from 1999 (11.47 CPE) to no catch made in 2000 (0 CPE) and remained the same in 2001. Although ruffe were not captured from the river in 2000, they were captured from Thunder Bay in the shipping channel. Ruffe comprised 2 percent of the total catch in Thunder Bay in 2000. Round goby were not found at any new locations during fall index surveys in 2000 or 2001; however, they continued to persist in areas where they were found in past years (Table 1). Surveillance findings for 2000 and 2001 are listed in Table 1.

We have not detected a spread in the range of ruffe to areas outside of the Thunder Bay area to date. The lack of range expansion may be due to the lack of suitable habitat for ruffe found in the shallow clear waters of surrounding areas of the bay and/or the quick response of the shipping industry to impose interim measures to prevent the transport of ruffe in ship ballast water out of the Alpena harbor (Harkins 1996). It is not known what has happened to the large increase in ruffe seen in 1999. It may be that the majority of the catch, which are YOY, may not be over-wintering. Adult ruffe have comprised only a small portion of the catch since 1996. The presence of round goby in the Thunder Bay River may also be having a negative affect on ruffe and native species as the total catch and species diversity have decreased to a large extent following the invasion of goby in the river in 1999.

The range of round goby has expanded in Lake Huron and their populations have rapidly increased in number. Beginning in 1997, the range of goby rapidly expanded along the U. S. Lake Huron coast to areas that are relatively separate from each other. Goby were discovered in Thunder Bay, Tawas Bay, and the Saginaw River, three very separate areas along the Lake Huron coast, over the past few years (A. Bowen, USFWS, survey data). This is interesting, as goby have not been detected in the AuSable River, lies between Thunder Bay and Tawas Bay, or the AuGres River, which is between Tawas Bay and the Saginaw River. It seems likely that there would be a progressive movement from one area to another if the goby had spread to these areas unassisted. Active shipping ports are located in goby infested areas of Thunder Bay, Tawas Bay, and the Saginaw River and all three of these locations are also primary fishing locations. These new populations may be the product of ballast water transfer from intra-lake shipping or accidental release of goby used as bait.

Although some measures have been taken to limit ballast transport of invasive fish in the Great Lakes, and bait vendors and fishermen have been educated about these invaders, their range continues to expand. The interim measures imposed by the Lake Carriers' Association in the Thunder Bay area may be one of the reasons that ruffe have not spread out of Alpena to other areas of Lake Huron or the Great Lakes; however, goby may be spread from port to port in other areas where these measures were not in place. Invasive fish surveillance around Lake Huron will be important in future years to document the baseline fish community and discover locations where ruffe and other invasives have spread.

Although it is illegal to transport any live invasive species in the State of Michigan (Public Act 451), anglers may also be accidentally spreading goby. Some anglers have been found to use goby as bait for predatory sportfish in certain areas of the Great Lakes where goby are abundant, such as the St. Clair River. Their success in using goby for bait in areas where they are abundant may encourage them to use goby in other areas where goby have not been found; thus essentially

spreading the range of this exotic through bait release. Goby are thought to have been introduced into the headwaters of the Shiawassee River, the upper reaches of the Saginaw River watershed, through the release of goby used as bait (Jude 1997).

Evaluation of native fish use of invasives as a diet items

In 1997 and 1998 the Alpena FRO initiated a predator diet analysis study to determine if ruffe and other invasives were being consumed in Thunder Bay, Lake Huron. Predatory fish were proposed as a method to control large ruffe populations in the St. Louis River, Lake Superior (Mayo et al. 1998). Predator diet analysis in the St. Louis River from 1991-94 indicated that northern pike (*Esox lucius*), walleye (*Stizostedion vitreum*), brown bullhead (*Ictalurus nebulosus*), smallmouth bass (*Micropterus dolomieui*), and yellow perch consumed ruffe following predator stocking (Mayo et al. 1998). Thunder Bay and the Thunder Bay River support populations of predators including natural reproducing smallmouth bass and northern pike and locally stocked brown trout (*Salmo trutta*) and walleye that could potentially be consuming ruffe.

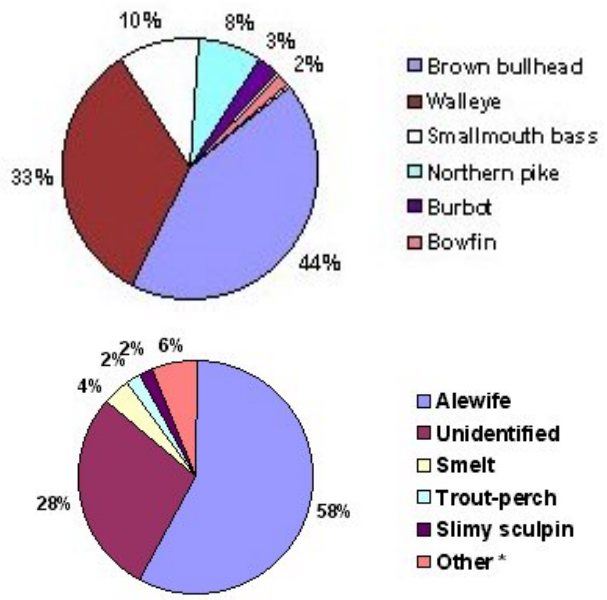

Figure 12. Species composition of predators (N=517) examined and species composition of prey fish in predators captured from the Thunder Bay River and Thunder Bay, Lake Huron in 1997-1998.

*** Other is a sum of: Emerald shiner, Johnny darter, Ninespine stickleback, Smallmouth bass, Spottail shiner, Round goby, and Walleye.**

Predatory fish were sampled from spring through fall during 1997 and 1998 at seven near shore sites in Thunder Bay and eight sites in the Thunder Bay River. A variety of sampling gears were used including experimental (1.8 m x 37.5 m of 5 - 7.5 m panels of stretch mesh sizes 3.8 cm, 5.1 cm, 6.3 cm, 7.6 cm, and 10.1 cm) and small mesh gillnets (1.2 m x 30 m of 3.8 cm stretch mesh), a semi-balloon bottom trawl (4.9 m width with 3.8 cm stretch mesh body and 12.7 mm stretch mesh cod liner), and boom electrofishing.

The diets of 517 predators from six species were examined for the presence of ruffe or goby (Figure 12). Similar numbers of stomachs were examined in 1997 (N=274) and 1998 (N=243); however, fewer species were examined in 1997 (four species) than in 1998 (six species). Sixty-seven percent of the predators were captured from the Thunder Bay River and 33% of predators were captured in Thunder Bay. Brown bullhead and walleye made up 44 and 33%, respectively, of predator stomachs examined (Figure 12). Bowfin (*Amia calva*) and burbot (*Lota lota*) were among the least represented, 2 and 3%, respectively.

Ruffe were not identified as a prey item and round goby were present as 1% or less of items consumed as prey (Figure 12). Approximately half, 46 %, of predator stomachs were void. Among

prey items, fish was the most common food category, 27 %, followed by aquatic insects, 15 %, crayfish, 7%, and miscellaneous items, 5 %. Alewife (*Alosa pseudoharengus*) was the most common fish prey consumed, occurring in 58% of predators that had consumed fish. Unidentifiable fish remains comprised 28 %, rainbow smelt (*Osmerus mordax*) comprised 4 %, and trout-perch and slimy sculpin each comprised 2 % of fish prey items consumed. Spottail shiner, emerald shiner, johnny darter, ninespine stickleback (*Pungitius pungitius*), smallmouth bass, walleye, and goby each represented 1 % or less of fish prey items consumed.

The dietary fish category contained unidentified fish remains, which could have included ruffe or goby. Although the number of ruffe captured from the Thunder Bay area had increased annually since 1995, it is possible that ruffe population abundance was too low for them to be encountered often by predatory fish and used as a major prey item. Their spiny morphology and their sensitive lateral line system (Ogle 1999) may increase their awareness of the presence of potential predators.

Predator diet analysis in the St. Louis River, Lake Superior in 1991-94 indicated that walleye, northern pike, brown bullhead, smallmouth bass, and yellow perch consumed ruffe following predator stocking (Mayo et al. 1998). Walleye and northern pike were the only predators that consumed a significant number of ruffe in the St. Louis River. In the Thunder Bay River walleye and northern pike were the only species examined that consumed only fish as a prey item. Based on this information, walleye and northern pike may be more likely to be the first predatory fish to encounter ruffe as a prey item in the Thunder Bay River. Walleye and northern pike are opportunistic feeders and are likely to feed on ruffe should their abundance increase.

Ruffe prefer bottom habitats (Ogle 1999) and bottom dwelling predators such as burbot and brown bullhead may also encounter ruffe as a prey item due to overlap of habitat. Burbot captured from the Thunder Bay River were found to eat juvenile yellow perch (A. Bowen, U. S. Fish and Wildlife Service, Alpena, Michigan, personal observation), which are morphologically similar in size and shape to ruffe. It is assumed that if ruffe abundance increases to significant levels, they will likely be used as a prey item by these local predatory fish.

A full report on this study titled "Evaluation of predator diets following ruffe colonization of Thunder Bay, Lake Huron 1997-1998" is available by request from our office or on our website (http://midwest.fws.gov/alpena/index.htm). A professional poster was also created based on this study titled "Evaluation of predator diets in Thunder Bay, Lake Huron".

Efforts to manage ballast water and regulate bait harvest to minimize invasive transport

In 1995, following the initial discovery of ruffe in Thunder Bay, the Alpena FRO contacted the Lake Carriers′ Association regarding the risks of transport of ruffe in ballast from Alpena to other areas in the Great Lakes. Coal and salt ships enter the river to deliver their goods for use by the county and local industry and many freighters enter Thunder Bay for commerce at the Lafarge Corporation cement plant (Figure 13). The risk of transport of the ruffe from Thunder Bay through shipping activities lead the Lake Carriers' Association to impose interim measures to reduce the risk of transfer of ruffe in ballast from the Alpena harbor to other areas of the Great Lakes (Harkins 1996.) The quick response of the shipping industry to the presence of ruffe in Alpena may be one

of the reasons that they have not spread to other areas of Lake Huron or the Great Lakes. This may be one of only a few areas in Lake Huron where measures have been imposed to limit ballast transfer of exotic fish species, and goby may have spread in other areas where these measures were not in place.

Efforts were also made in 1996 to assist in the regulation of bait harvest and possession in infested areas of Lake Huron to prevent the transport of invasives. The Alpena FRO and Michigan DNR met with harvesters that collect bait in Alpena, Michigan and developed a protocol to screen harvested bait. The protocol has not been fully implemented.

Figure 13. A ship unloads salt at the Thunder Bay River port on Lake Huron. Large vessels enter the river to deliver salt or coal for use by the county and local industry.

Support to prevent the movement of Great Lakes invasives into the Mississippi watershed

In an effort to prevent their spread into the Mississippi River, Alpena FRO has supported and actively assisted in surveillance and control trawling and trapping for round goby and other exotics in the Chicago Shipping and Sanitary Canal and the Illinois Waterway annually since 1994. The Service's LaCrosse FRO, located in LaCrosse, Wisconsin, coordinates these efforts to document the spread of round goby in these tributaries to the Mississippi. Many federal, state, and community agencies cooperate in this effort. The Alpena FRO has provided a trawling vessel and operator in assistance to support this effort.

Development and promotion of education programs to identify and report invasive species

Detecting invasive species prior to population expansion and impact on native species is vital to controlling these species. Critical to early detection is the education of public waterway users about how to identify invasives, how they are spread, concerns, and how they can help to prevent their spread. Public education and invasive sighting reporting is important in early detection. Alpena FRO has been active in this area.

As a means to educate large numbers of anglers and water users along the Lake Huron coast about invasives, Alpena FRO developed a poster titled "Ruffe in Lake Huron" (Figure 15). The poster included information on the 1995 discovery of ruffe in Lake Huron, provided identifying characteristics, and encouraged anglers to report any sightings. The posters were placed at boat launches, fish cleaning stations, marinas, and bait shops from Sault Ste. Marie to Harbor Beach in Michigan along the Lake Huron shoreline.

In addition to posters, the Alpena FRO has distributed thousands of ruffe and goby "WATCH" cards that were developed by Sea Grant and the USFWS to assist anglers and waterway users about

the problems associated with these species. The cards, which are water resistant, show a color photo and characteristic diagrams to aid in proper identification. Contact information for our office as well as other local management agencies is provided along with what an angler should do to report the sighting. Cards are distributed annually to bait and tackle dealers, chamber of commerce offices, and marinas from Sault Ste. Marie to Harbor Beach in Michigan along the Lake Huron coast. A brochure titled "A Field Guide to Aquatic Exotic Plants and Animals" has also been distributed that includes characteristics and problems associated with a range of aquatic invasives including the purple loosestrife, zebra mussel, and sea lamprey.

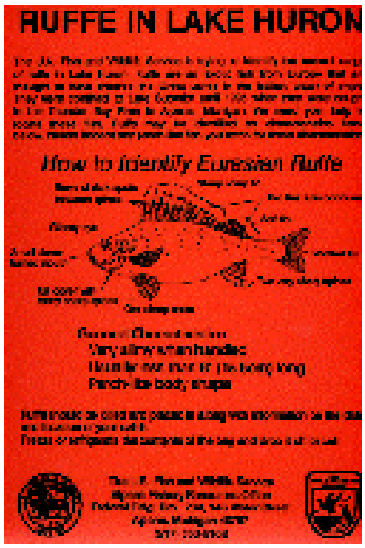

Figure 14. Posters were developed to assist with ruffe education and sighting reports on Lake Huron.

As a result of educational efforts, we received numerous annually reports from anglers regarding sightings of suspected invasive species. Many have provided specimens to confirm new locations of invasive populations. In past years, anglers reported the first confirmed sightings of round goby in Alpena (1997), Tawas (1998), Harbor Beach (1998), Presque Isle (1999), Caseville (1999), AuGres (2000), Linwood (2001), and Bay Port (2001).

Alpena FRO has given presentations on aquatic nuisance species in Lake Huron at a number of professional meetings including the Midwest Fish & Wildlife Conferences (1999), Great Lakes Fishery Commission's Upper Lake Committee Meetings (2000, 2001), and Native American Fish & Wildlife Society - Great Lakes Region Conferences (2001); and co-authored presentations given at the International Association of Great Lakes Research (2000). Poster presentations have also been developed and presented at the Service's Biologist Conference (1999). Information on invasives in Lake Huron is also provided at a professional level through membership and attendance at task group meetings – including the Ruffe Control Committee and St. Marys River Fishery Task Group. Alpena FRO has actively participated, contributed, and presented information on Lake Huron invasives at Ruffe Control Committee meetings.

We are able to reach waterway users on a local level to target specific areas through providing educational presentations at conservation club meetings, hosting and participating in school programs, and annual representation at festivals and outdoor shows. We are able to provide preserved specimens for display and printed information including the identification cards. We have also provided invasive species educational materials to fishermen fishing in area fishing competitions and to anglers on the St. Marys River during a concentrated effort to determine sport and tribal harvest from May 1999- March 2000. Outdoor shows cover areas statewide and include Outdoorama (Novi, est. 1994); Traverse City Hunting & Fishing Expo (Traverse City, est. 2001); Oscoda Fishing and Boating Expo (1998, 2002); River Fest (Alpena, est. 2000); and Alpena Lighthouse Festival (Alpena, est. 1997).

Alpena FRO has also provided preserved invasive specimens - including ruffe, goby, sea lamprey, and rusty crayfish - to a number of colleges, universities, and high schools in the US and Canada for

identification and educational purposes. They have also been provided to other state and federal offices for the same purpose.

Beginning in 1999, Alpena FRO expanded educational information to the world via the World Wide Web through posting of invasive information on our office website located at http://midwest.fws.gov/alpena/index.html. All projects, reports, and links for further information are posted in addition to basic education on invasive identification and prevention.

We also maintain a display within our facility located in the Alpena Federal Building where we provide invasive educational materials at a kiosk located in the lobby and educational posters on display.

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