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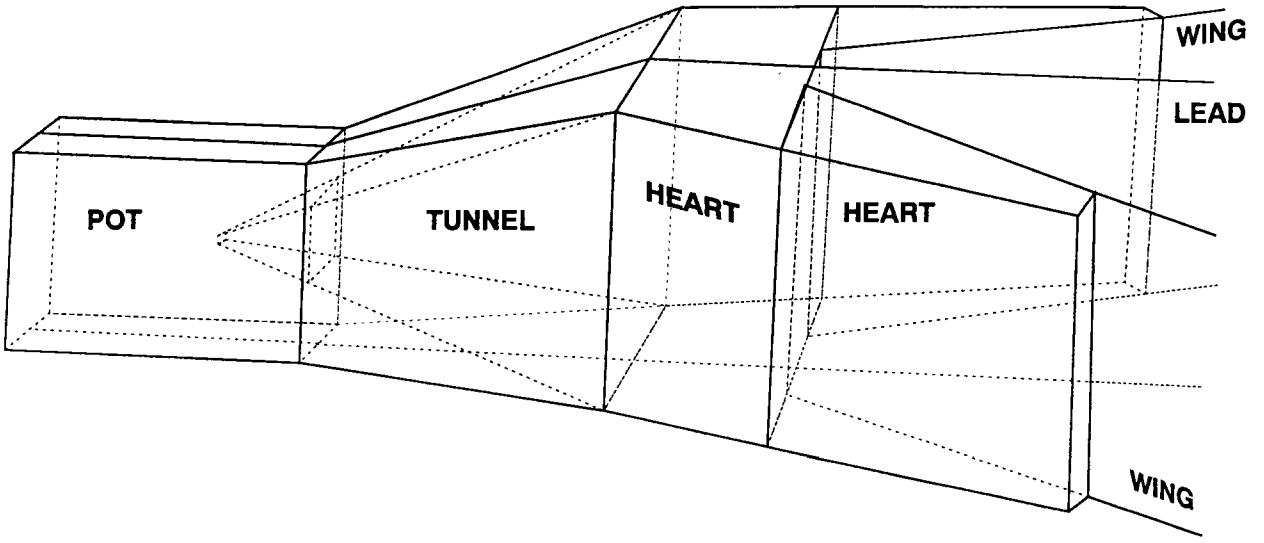

STATE OF MICHIGAN
DEPARTMENT OF NATURAL RESOURCES

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Catch and Mortality of Non-Target Species in Lake Whitefish Trap Nets in Michigan Waters of Lake Superior

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Abstract.—Trap nets have been promoted as an efficient means for harvesting lake whitefish *Coregonus clupeaformis* in the Great Lakes while limiting mortality to other (non-target) species. All state-licensed fisheries for lake whitefish in Michigan waters of Lake Superior use trap nets. During 1983-1989, these fisheries were sampled annually to estimate catch and mortality of non-target species. The samples represented 9% of the total trap-net effort by these fisheries. Non-target fishes killed annually by state-licensed trap nets in Michigan waters of Lake Superior, with mean annual catch in parentheses, were estimated as: 131 (19,721) sublegal lake whitefish, 414 (11,341) lake trout *Salvelinus namaycush*, 26 (37) coho salmon *Oncorhynchus kisutch*, 6 (15) chinook salmon *O. tshawytscha*, 6 (11) rainbow trout *O. mykiss*, 12 (55) brown trout *Salmo trutta*, 41 (143) lake herring *Coregonus artedii*, 39 (67) round whitefish *Prosopium cylindraceum*, and 0 (48) lake sturgeon *Acipenser fulvescens*. All dead fish were gilled in the pot portion of trap nets. The only non-fish species observed in trap nets was the common loon *Gavia immer*. The estimated annual catch of common loon was 263, with 86% of these caught in trap-net hearts. The mortality rate for loons in trap nets was 100%. No modifications of trap nets or fishing restrictions were recommended to reduce catch and mortality of non-target fishes in Lake Superior. However, we recommend that mesh size in the top of the hearts be increased to 14-in stretch mesh to reduce catch and mortality of common loons.

The lake whitefish *Coregonus clupeaformis* has been the most important commercial species in Michigan waters of Lake Superior for more than a decade. Lake whitefish catch and effort have increased since the 1960's for traditionally exploited stocks (Rakoczy 1983), and exploitation of new stocks is planned or already started under research permits issued by the Michigan Department of Natural Resources (MDNR). Fisheries for other species such as lake trout *Salvelinus namaycush*, lake herring *Coregonus artedii*, or chubs *Coregonus* spp. have either been closed by regulation or greatly reduced by depressed markets.

MDNR has been concerned with mortality of non-target species, particularly lake trout, in all of its state-licensed fisheries. Assessment of incidental catch of trout and salmon in gill nets during the late 1960's indicated that use of this gear to harvest lake whitefish would greatly hinder efforts to rehabilitate lake trout populations and develop sport fisheries in Michigan waters.

Use of gill nets by the state-licensed commercial fishery was prohibited in depths shallower than 50 fathoms in 1970, and shallower than 60 fathoms in 1974. Since lake whitefish have not been found in water 60 fathoms and deeper (Dryer 1966, Reigle 1969), state-licensed or state-permit fisheries have used only trap nets to harvest lake whitefish in Lake Superior since 1974. Trout, salmon, and other fishes not specified as part of the legal trap-net catch must be returned to the water dead or alive, and trap nets may not be fished in water deeper than 90 feet to afford some protection for lake whitefish in part of their habitat. Although most fish caught in trap nets can be released alive, some mortality has been reported (Van Oosten et al. 1946; Eshenroder 1980; Schneeberger et al. 1982; Smith 1988). This mortality occurred mainly when fish gilled in the pot. Lake trout gilling and mortality in trap nets was sufficiently high in lakes Huron and Michigan to warrant evaluations of trap-net modifications designed to reduce gilling (Eshenroder 1980; Schneeberger et al. 1982; Smith 1988). Some other factors that may cause fish mortality in trap nets include expansion of gases in the swim bladder when the net is lifted (bloating), predation by fish-eating birds after being returned to the water, and trauma of confinement in the net.

No studies had been conducted on non-target catch and mortality for trap nets in Lake Superior. Anglers generally oppose new or expanding commercial fisheries because they fear a significant negative impact on sport-fish populations. MDNR has promoted trap-net fisheries based on the hypothesis that non-target mortality in trap nets is substantially less than in gill nets, and that expansion or creation of trap-net fisheries will not harm sport-fish populations. We needed data on non-target catch and mortality in trap nets in Lake Superior to determine if our hypothesis of no significant mortality of non-target species in trap nets was correct.

The objective of this study was to determine the catch and mortality of species other than legal-size lake whitefish in commercial trap nets fished in Michigan waters of Lake Superior, and to recommend fishing strategies or gear modifications to reduce this mortality where necessary.

Methods

Non-target mortality in trap nets was determined for state-licensed lake whitefish fisheries operated at Upper Entry, Bete Grise, Big Bay, Marquette, and Munising during 1983-1989 (Figure 1). These fisheries were allowed retention of legal-size lake whitefish, longnose suckers *Catostomus catostomus*, white suckers *C. commersoni*, burbot *Lota lota*, and common carp *Cyprinus carpio*. All other species were to be returned to the water dead or alive. Legal size of lake whitefish was 17 inches total length for most locations and dates; it was 19 inches for Upper Entry during 1983-1985 and for Big Bay during 1983-1987. In reality, legal lake whitefish were the only target species in the state-licensed fishery because suckers, burbot, and carp had little market value and were rarely retained. Suckers, burbot, and common carp were evaluated as non-target species in this study.

The trap nets were of similar design, but measurements may have differed slightly. In general, pots were 40 feet long by 20 feet wide by 20-40 feet deep, with 100-foot wings and a lead up to 1,000 feet long. The lead and wings converged at a series of one or more chambers (hearts) which incorporated the net entrance and tunnel leading to the pot (Figure 2). Mesh was tarred nylon with mesh sizes (stretched measure) of 4.5 inches in the pot, 6 inches in the wings and hearts, and 12 to 14 inches in the lead.

The fishing season for trap nets is generally May to October. May is usually the earliest month fished because fishermen prefer not to set nets until the lake is ice-free. October is usually the last month fished because the season is closed in November and winter storms and ice preclude fishing thereafter until spring. Some fishing was done in April and December in 1987-1989

because warm winters resulted in less than normal ice formation.

Personnel from Marquette Fisheries Station accompanied the fishermen on their boat and sampled catches 1-7 days per month. Assistance was provided by personnel from District 2 Fisheries at Upper Entry in 1983 and personnel from District 1 Fisheries at Bete Grise in 1983. Sampling was done each month fished at Upper Entry during 1983-1987, but was restricted to July-August in 1988 and June in 1989. Sampling on the other fishing grounds was usually during June and July. Data recorded for each net included date, location (statistical grid), days fished, and water depth at the pot. Data recorded for the catch in each net were the number of each species alive and free in the pot, the number dead and free in the pot, the number gilled that were alive, and the number gilled that were dead. Live fish that were bleeding or otherwise appeared injured were counted as dead. Most of the heart portion of the net was visually inspected for gilled fish during each lift. The portion of the heart most distant from the pot, the wings, and the lead were not examined.

Catch (number or pounds), gilling (number gilled), and mortality (number killed) was expressed on a per unit of fishing effort basis, which was per trap-net lift. A "lift" was each time fish were removed from a trap net; nets were generally lifted every 4 days. One exception was at Upper Entry where nets were lifted every 2 days during 1983-1985. We did not adjust effort for days fished between lifts, so it is possible that catch per trap-net lift at Upper Entry in 1983-1985 could have been somewhat higher had nets been fished 4 days instead of 2. Hamley and Howley (1985) reported that catch increased proportionally between trap nets fished 1 to 3 days, but not beyond that. However, variation associated with catch per trap-net lift was of sufficient magnitude that it would likely preclude identification of any real differences due to days fished. Smith (1988) found no correlation between 3- to 6-day lift intervals and catch or mortality of lake trout. Because sampling at Upper Entry in 1983 and 1984 spanned what is typically the trap-net fishing season (May-October), these data were used to present a seasonal picture of catch, gilling, and mortality for lake trout, and catch for the other salmonines, lake sturgeon *Acipenser fulvescens*, and the common loon *Gavia immer*.

Differences in catch, gilling, and killing rates were determined to be significant if 95% confidence intervals calculated for means did not overlap. The total number of non-target species caught, gilled, and killed in all of Michigan's state-licensed trap-net fishery was estimated by multiplying the appropriate mean rate per trap-net lift in sampled trap nets on each fishing ground by the total number of trap-net lifts reported for that ground.

Results

Non-target catch and mortality was determined from 1,012 trap-net lifts sampled on 164 days at five fishing grounds during 1983-1989 (Table 1). The percentage of total lifts sampled ranged from 6% at Marquette to 13% at Upper Entry and averaged 9% for all fishing grounds. Upper Entry and Munising were the most intensively sampled fishing grounds.

Non-target catch in trap-net fisheries for lake whitefish consisted mainly of sublegal lake whitefish and lake trout. Other fishes less frequently caught were lake sturgeon, coho salmon *Oncorhynchus kisutch*, chinook salmon *O. tshawytscha*, rainbow trout *O. mykiss*, brown trout *Salmo trutta*, lake herring, round whitefish *Prosopium cylindraceum*, longnose sucker, white sucker, common carp, and burbot. The only non-fish species found in the trap nets was common loon. Sublegal lake whitefish, lake trout, suckers, and common loon were captured on all fishing grounds. The greatest number of species were found on the Upper Entry and Munising fishing grounds (Tables 2-6).

Sublegal lake whitefish

Sublegal lake whitefish were captured on all fishing grounds and were the most abundant non-target fish in trap nets (Tables 2-7), except at Marquette where catch per trap-net lift of lake trout was higher (Table 5). Mean total catch per lift of sublegal lake whitefish from all grounds was quite variable among years, ranging from 3.7 in 1989 to 25.5 in 1985 (Table 7). Catches of sublegal whitefish on individual grounds were even more variable, with wide confidence intervals indicating highly variable within-year catches. At Upper Entry, catch per trap-net lift of sublegal whitefish ranged from 1.3 in 1989 to 40.0 in 1985. This high catch in 1985 prompted the Upper Entry fisherman to petition for a lowering of the size limit to 17 inches. The size limit was changed from 19 inches to 17 inches in 1986, but catch of sublegal lake whitefish did not significantly decline (Table 2). The greatest difference in catch per lift among years occurred at Bete Grise where catch per lift ranged from 0.7 fish in 1986 to 68.8 in 1985 (Table 3). Catch per lift at Big Bay ranged from 5.3 in 1988 to 35.3 in 1983 (Table 4). The change from a 19-inch to a 17-inch size limit at Big Bay in 1988 may have been responsible for decreased catches of sublegal lake whitefish in 1988 and 1989. Catches at Marquette were consistently low, ranging from 1.3 in 1989 to 6.9 in 1985 (Table 5). Catches at Munising were higher than at Marquette but lower than at all other fishing grounds, ranging from 4.0 in 1985 to 17.0 in 1983 (Table 6).

The number of sublegal lake whitefish gilled and killed per trap-net lift were so variable that comparisons could not be made among years on individual grounds (Tables 2-6). No fish were observed gilled on any ground in 1988 and 1989 except Upper Entry. The highest observed gilling rate was 3.00 at Big Bay in 1983. The mean number of sublegal lake whitefish gilled per lift during 1983-1989 ranged from 0.08 at Munising to 0.63 at Upper Entry and Bete Grise. No fish were observed killed on any ground during 1986, 1988, and 1989 except at Upper Entry. The highest observed killing rate was 1.45 at Bete Grise in 1983. The mean number killed per trap-net lift during 1983-1989 ranged from 0.01 at Munising to 0.37 at Bete Grise. The mean numbers caught, gilled, and killed per net lift on all grounds during 1983-1989 were 12.2, 0.31, and 0.07 respectively (Table 7). The numbers gilled and killed were 3% and 1% of the estimated 19,721 sublegal lake whitefish caught. The estimated number of sublegal lake whitefish killed annually during 1983-1989 in Michigan's state-licensed trap-net fishery was 131, with as few as 2 at Big Bay and as many as 68 at Bete Grise (Table 8).

Lake trout

Lake trout were captured in sampled trap nets on all fishing grounds, with the highest mean catch per trap-net lift at Marquette and Upper Entry, and the lowest at Bete Grise (Tables 2-6). The number of lake trout killed per trap-net lift was highest at Marquette and lowest at Munising, but no significant difference in mortality rates could be detected among any fishing grounds.

At Upper Entry, mean numbers of lake trout caught, gilled, and killed per trap-net lift were 9.4, 1.09, and 0.33, respectively (Table 2). Annual lake trout catch per net lift was highest in 1983 and lowest in 1987, but only 1987 was significantly different from the mean of 9.4. The mean number of lake trout gilled per trap-net lift each year at Upper Entry was similar to the overall 1983-1989 mean of 1.09. The number of lake trout killed per lift was somewhat more variable, but only the high of 0.97 in 1988 and low of 0.02 in 1985 were significantly different from the mean of 0.33. The estimated numbers of lake trout caught and killed annually during 1983-1989 at Upper Entry were 3,751 and 132 (Table 8).

At Bete Grise, the mean numbers caught, gilled, and killed per trap-net lift were 2.6, 0.49, and 0.19, respectively (Table 3). There were no significant differences

among years for any of the three rates. The estimated numbers of lake trout caught and killed annually at Bete Grise during 1985-1987 were 552 and 35 (Table 8).

At Big Bay, the mean numbers caught, gilled, and killed per trap-net lift were 6.0, 0.68, and 0.28, respectively (Table 4). The highest catch per lift was in 1983, but catch that year was based on only four trap-net lifts and this small sample size resulted in very high variation. Ignoring 1983, the catch and number gilled per net lift were highest in 1986 and lowest in 1987, and values for these two years were significantly different. No lake trout were observed killed at Big Bay in 3 of the 7 years, and a significant difference in mortality rates among the remaining 4 years could not be established. The number of lake trout caught and killed annually at Big Bay during 1983-1989 were estimated at 660 and 31 (Table 8).

At Marquette, the mean numbers caught, gilled, and killed per trap-net lift were 11.4, 1.23, and 0.34, respectively (Table 5). The highest catch per lift was in 1985 and lowest in 1989. Catches per lift in 1985 and 1984 were significantly higher than in 1987, 1988, and 1989. The highest number gilled per trap-net lift was in 1985 and lowest in 1988. The number gilled per lift in 1985, 1984, and 1983 were significantly higher than in 1988. No lake trout were reported killed at Marquette in 1986 and 1988, and the mean number killed per trap-net lift in the other years were not significantly different. The estimated numbers of lake trout caught and killed annually at Marquette were 3,468 and 107 (Table 8).

At Munising, the mean numbers caught, gilled, and killed per trap-net lift were 4.3, 0.49, and 0.16, respectively (Table 6). There was little difference among years for the respective parameters, except that in 1989 catch was significantly lower than in all other years and no fish were gilled or killed. The estimated numbers of lake trout caught and killed annually at Munising were 2,910 and 109 (Table 8).

Based on catch at Upper Entry, most lake trout were taken during June (31%), May (20%), and August (19%). The number caught per trap-net lift was greatest in May both in sampled nets and in all nets reported by the fishery from 1983-1984 (Table 9). Lake trout were also abundant in samples collected in August-September 1983 and June 1984. Catches of lake trout reported by the commercial fishery at Upper Entry were generally less than reported from sampled nets, but this difference was not significant in either 1983 or 1984. Monthly numbers of lake trout gilled and killed per trap-net lift were inconsistent between 1983 and 1984. In 1983, the highest gilling rate occurred in August and the lowest in October, whereas the highest number killed per lift was in September and the lowest in August. In 1984, the highest gilling rate was in June and the lowest in August, whereas the highest number killed per lift was in July and none were killed in May and August. The number of lake trout killed per trap-net lift was not estimated for May-July 1983. Few of the differences noted for lake trout caught, gilled, and killed in sampled nets were significant.

Lake trout mortality did not appear to be influenced by depth at Upper Entry in 1983-1984. Catch, number gilled, and number killed per trap-net lift for deep (51-90 ft) or shallow locations (30-50 ft) were 11.8±3.1 and 14.5±4.4, 1.5±0.6 and 1.4±0.5, or 0.5±0.3 versus 0.2±0.1, respectively. None of these values differed significantly.

There were significant correlations ($P < 0.01$) between number of lake trout caught per trap-net lift and number gilled per trap-net lift ($r=0.528$, $N=864$), between number caught per trap-net lift and number killed per trap-net lift ($r=0.231$, $N=864$), and between the number gilled per trap-net lift and number killed per trap-net lift ($r=0.480$, $N=389$). There were also significant correlations between catch of legal lake whitefish and number of lake trout caught ($r=0.143$, $N=1,012$) and gilled ($r=0.105$, $N=1,012$),

but no significant correlation ($P > 0.05$) between legal lake whitefish catch and number of lake trout killed ($r=0.049$, $N=1,012$). Although significant, these correlations generally explained less than 50% of the variation in dependent variables, and therefore some other factor or even chance may be more important in affecting number of lake trout caught, gilled, and killed in trap nets.

Mean annual numbers of lake trout caught per trap-net lift for all grounds were consistently close to the overall mean of 7.19 fish per lift, with a low of 4.07 in 1987 and high of 9.84 in 1983 (Table 7). The mean number of lake trout gilled per lift was 0.83, which made up 12% of the catch. The highest number of lake trout gilled per lift was 1.23 in 1983 and the lowest was 0.57 in 1986. Lake trout gilled mainly in sides of the pot (34%) and in the top over the tunnel (24%). Lake trout also gilled in the back (12%), front corners (11%), rear corners (11%), front (5%), bottom (2%), and hearts (1%). The numbers of lake trout killed per trap-net lift were more variable among years than numbers gilled, with an overall mean of 0.26, a high of 0.47 in 1989, and a low of 0.04 in 1985. The total estimate of lake trout killed annually from 1983-1989 in state-licensed trap nets was 414, which was 4% of the mean annual catch of 11,341.

Lake sturgeon

Lake sturgeon were found in sampled trap nets on all fishing grounds except Bete Grise (Tables 2-6). Catch per trap-net lift ranged from 0.02 at Marquette and Munising to 0.07 at Big Bay, but catches among years for each fishing ground were highly variable so significant differences among fishing grounds were not evident. Lake sturgeon were caught most consistently at Big Bay. The mean catch per trap-net lift for all grounds was 0.03 (Table 7). At Upper Entry, lake sturgeon were caught during May (7%), June (50%), July (29%), and October (14%). An estimated 48 lake sturgeon were captured annually in state-licensed trap nets during 1983-1989, and no gilling or mortality were observed (Table 8).

Coho salmon, chinook salmon, and rainbow trout

Coho salmon, chinook salmon, and rainbow trout were rarely found in sampled trap nets. None of these species were recorded at Big Bay and Marquette, and only coho were captured at Bete Grise (Tables 2-6). All three species were found at Upper Entry and Munising, but catch per trap-net lift ranged only from 0.02 to 0.03 for coho salmon and 0.01 to 0.02 for chinook salmon and rainbow trout. Mean catches per trap-net lift for all three species on all grounds were 0.02, 0.01, and 0.01, respectively (Table 7). At Upper Entry, coho salmon were caught during June (17%), August (17%), and September (66%), whereas chinook salmon and rainbow trout were captured only in June. Estimated annual catches of coho salmon, chinook salmon, and rainbow trout on all grounds were 37, 15, and 11, respectively (Table 8). The percentages of these fish that were gilled in the net were 79%, 55%, and 50%, respectively, and percentage of gilled fish which were dead was 67-100%. The total estimated number of coho, chinook, and rainbow killed annually on all fishing grounds were 26, 6, and 6, respectively.

Brown trout

Brown trout were more numerous than salmon or rainbow trout in trap-net catches. They were found in sampled trap nets on all grounds except Bete Grise, with overall mean catch per trap-net lift ranging from 0.01 at Marquette and Munising to 0.09 at Upper Entry (Tables 2-6). The mean catch per net lift on all grounds was 0.05 (Table 7). At Upper Entry, brown trout were caught during May (5%), June (58%), July (32%), and October (5%). Most brown trout were

free-swimming in the net and released alive, but 24% were gilled in the pot. On one occasion, a few brown trout encountered the pot from outside and gilled. Practically all (90%) gilled brown trout were dead. The estimated annual catch of brown trout in state-licensed trap nets on all fishing grounds was 55, and estimated mortality was 12 (Table 8).

Lake herring

Lake herring were found in sampled trap nets at Upper Entry, Big Bay, and Munising (Tables 2-6). Catch per trap-net lift ranged from 0.03 at Munising to 0.57 at Big Bay, but catches among years on each fishing ground were highly variable and differences in catch among grounds were not evident. The mean catch per net lift of lake herring on all grounds was 0.12 (Table 7). Twenty-nine percent of lake herring caught on all grounds were gilled in the pot. The estimated annual catch of lake herring in state-licensed trap nets on all fishing grounds during 1983-1989 was 143 (Table 8). Reliable data on mortality was not collected, but it could be as high as 41 fish assuming that all gilled fish died.

Round whitefish

Round whitefish were found in sampled trap nets at Upper Entry, Bete Grise, and Munising (Tables 2-6). Catches per trap-net lift ranged from 0.01 at Munising to 0.14 at Upper Entry, but catches among years on each fishing ground were highly variable and no significant differences were found in catch among grounds. Mean catch per trap-net lift on all grounds was 0.05 (Table 7), and mean number caught per year was 67 (Table 8). Precise data on mortality of round whitefish was not collected. If the reported 59% gilled all were dead, the mortality would be 39 fish per year.

Suckers, common carp, and burbot (miscellaneous)

White suckers, longnose suckers, common carp, and burbot were combined into a miscellaneous category because suckers were not separated by species in sampled lifts, carp and burbot were rarely captured, and none of these fish were important sport or commercial species in Lake Superior. Suckers made up over 90% of this miscellaneous category. These miscellaneous species were found in sampled trap-net lifts on all fishing grounds. Catch per trap-net lift ranged from 0.33 at Bete Grise to 2.68 at Big Bay (Tables 2-6). The mean catch per trap-net lift on all grounds was 1.59, with a low of 0.48 in 1988 and a high of 2.99 in 1985 (Table 7). The mean annual catch of these species on all fishing grounds was 2,559 (Table 8). Retention of these species was permitted in the fishery, but few were retained. Less than 1% of the suckers (15 fish) were dead in the nets and all of these were gilled. No mortality was observed for carp and burbot.

Common loon

The common loon was captured on all fishing grounds and was more abundant in sampled trap-net lifts than many fish species. Numbers caught per trap-net lift ranged from 0.07 at Big Bay to 0.23 at Munising (Tables 2-6). Most common loons were found in hearts (86%), but some made it into the pot (14%). Mean catch per trap-net lift on all grounds was 0.15 (Table 7). At Upper Entry, common loons were caught all months during May-October, but mainly during June (44%) and July (22%). The estimated annual catch in state-licensed trap nets on all fishing grounds was 263, with lowest catch at Big Bay and the highest catch at Munising (Table 8). Mortality was 100% for common loons in trap nets.

Discussion

Trap nets used by Michigan's state-licensed commercial fisheries in Lake Superior harvested mainly the targeted lake whitefish and caused minimal mortality to other fish species. The mean catch of 248.4 lb of legal lake whitefish equated to 83 fish per lift (assuming 3.0 lb per fish, Marquette Fisheries Station, unpublished data) which was about 80% of all fish caught per trap-net lift. Few legal whitefish were gilled in these nets, which agrees with data reported for trap nets in Lake Michigan (Smith 1988). All species of trout and salmon known to occur in Lake Superior except brook trout *Salvelinus fontinalis*, splake *Salvelinus fontinalis x namaycush*, Atlantic salmon *Salmo salar*, and pink salmon *Oncorhynchus gorbuscha* were observed in the trap nets. These four are much less common than other trout and salmon in Lake Superior, and most are too small to be vulnerable to these nets. Walleye *Stizostedion vitreum* and northern pike *Esox lucius* have been previously observed in trap nets from Michigan waters of Lake Superior (Marquette Fisheries Station, unpublished observations), but are uncommon and were not observed in this study. Smith (1988) reported similar catch of trout and salmon for trap nets in Lake Michigan as we reported in Lake Superior. Smith (1988) also found yellow perch *Perca flavescens* and walleye abundant in Lake Michigan nets, but did not report capturing any other of the non-salmonine species observed in Lake Superior nets, including common loon. No other studies have documented non-target species in trap nets other than sublegal whitefish and lake trout. Schneeberger et al. (1982) reported that the capture of species other than lake trout was negligible in a Lake Huron trap-net fishery, but did not identify species composition.

All dead fish observed in this study were gilled in trap-net pots, although a few lake trout were gilled in the hearts. A portion of the hearts and all of the wings and lead were not examined, but the large mesh size in these areas and the tendency for most fish species to lead should have minimized gilling and mortality there. No fish mortality was observed due to pressure changes when the net was lifted, even from the maximum depth allowed (90 ft). Viable fish which were returned to the water sounded immediately and were not taken by fish-eating birds.

Sublegal lake whitefish were the most numerous non-target fish taken, but made up less than 3% of the total lake whitefish catch and practically all were released alive. Some gilling and mortality rates at Upper Entry and Big Bay were higher under the 19-inch length limit than under the 17-inch limit, but data were too variable to establish that the difference was significant. Increasing the minimum size limit from 17 to 19 inches has been considered as a measure to allow adequate escapement of spawning stock and increase yield to fisheries in Lake Michigan (Rybicki and Schneeberger 1990). Our data indicate that gilling and mortality would not be important factors to consider in proposing a similar increase in minimum size limit for Lake Superior.

Lake trout were readily captured in trap nets on all fishing grounds during most months of the fishing season and at all depths fished, but only about 3.7% of those captured were killed. Our data indicated that lake trout mortality was related to number caught in a net lift, but was not influenced by month or depth fished. Lake trout abundance decreased on a number of these fishing grounds during the 1980's (Peck and Schorfhaar 1991), so mortality of lake trout in trap nets should remain low and decrease. The catch and mortality rates for lake trout in trap nets on Lake Superior fishing grounds were considerably less than in trap nets in Lake Michigan and Lake Huron. Smith (1988) reported catches of 72-88 lake trout per net lift and mortalities of 2.3-5.2 per lift in Lake Michigan at Muskegon. In Lake Huron, Schneeberger et al. (1982) reported lake trout catches per lift of 4-173 (about 75 per lift average), and gilling rates of 4.2 per lift, of which 27% died (1.1 per lift).

Lake trout mortality was caused by gilling, mainly in the sides of the pot. Smith

(1988) also reported that lake trout gilled mainly in the sides of trap-net pots in Lake Michigan, but Eshenroder (1980) reported that most fish gilled in the top and corners of pots for trap nets he observed in Lake Huron. Eshenroder (1980) determined that sewing smaller mesh into the corners and top of the pot over the tunnel reduced gilling, but Smith (1988) found no difference in number gilled per net lift in trap nets modified as recommended by Eshenroder (1980) compared to unmodified trap nets in Lake Michigan. In modified nets, lack of gilling in the corners and top was apparently offset by increased gilling in other areas of the pot, especially the sides. Most gilling in trap nets appears to take place when the net is lifted. Schneeberger et al. (1982) reported that 73% of gilled fish in Lake Huron trap nets became gilled during the net lift.

Other trout and salmon species were little affected by trap nets in Lake Superior. Brown trout was second in abundance to lake trout, but gilling and mortality rates were low. Gilling and mortality were much higher for coho salmon, chinook salmon, and rainbow trout, but these species were less frequently caught than brown trout. Pacific salmon and rainbow trout were more abundant than brown trout in Lake Superior during this study (Peck 1992), so the greater catch of brown trout may have been due to different depth distributions, geographic distributions, or behavior when encountering a net. Behavior was also apparently different among salmonines once they were in the net. Lake trout and brown trout were less likely than other trout and salmon to gill and die in these trap nets, and Smith (1988) reported similar findings in Lake Michigan. Smith (1988) reported much higher catch rates for these other trout and salmon in Lake Michigan than we observed in Lake Superior.

The lake sturgeon is classified as threatened in North America (Williams et al. 1989) but was not commonly taken by trap nets in Lake Superior. All sturgeon observed were free swimming in the net and released in apparent good health. A sturgeon marked by the fisherman at Upper Entry was caught and released several times. Mortality of lake sturgeon may have occurred if they gilled in the larger-mesh trap-net lead, but this was not checked by MDNR and not reported by the fishery.

Lake herring and round whitefish populations were not affected much by trap nets during 1983-1989, because few were caught and most of these were released alive. Even though lake herring biomass in Lake Superior increased in 1985-1986 (Hansen 1990), trap-net catches did not reflect this increase. Possibly, lake herring representing that biomass were not yet big enough to be retained in the nets, or their behavior may cause them to avoid the nets. If lake herring populations continue to grow in numbers and size, catches in trap nets should increase, but it is likely that most of these fish would be released alive. Round whitefish rarely get longer than 18 inches and most are less than 14 inches in Lake Superior (Bailey 1963). Round whitefish should not be vulnerable to trap nets unless mesh size in the pot is decreased.

Although retention of suckers, common carp, and burbot is allowed, retention of these species is low in the trap-net fishery for lake whitefish, and will remain low unless markets for these species improve.

Because gilling and mortality of non-target fishes were low, were apparently not influenced by month or depth fished, and the effectiveness of net modifications reported in other studies was questionable, we recommend no net modifications or other restrictions on state-licensed trap-net fisheries for lake whitefish in Lake Superior. The numbers of trout and salmon killed by state-licensed trap nets should have little or no impact on the sport fishery for these species. The total number of lake trout killed annually in trap nets on all fishing grounds in Lake Superior was less than 3% of those killed in Michigan's sport fishery in Lake Superior (Rakoczy and Rogers 1990). Other trout and salmon were even less vulnerable, with the estimated kill of chinook salmon and rainbow trout in trap nets being no more than the daily possession limit for two Michigan

anglers (6 fish). Even if all captured salmon and rainbow trout died, this is still a rather small loss. Anglers rarely complain about sport fish being caught in trap nets in Lake Superior. The nets themselves are of greater concern to anglers because they are sometimes obstacles to trolling. Although nets are required to be well marked, anglers occasionally fish over nets because fishing lures are sometimes found tangled in the net.

Trout and salmon mortality in gill nets is considerably higher than in trap nets. Commercial fisheries by Native Americans in Lake Superior used gill nets exclusively on the same grounds fished by state-licensed trap nets, and used mainly gill nets in the remaining Michigan waters. The annual catch of trout and salmon in tribal gill nets was much greater than in state-licensed trap nets, with annual catches during the late 1980s of about 75 rainbow trout, 5,000 coho salmon, 100 chinook salmon, and 200,000-300,000 lbs of lake trout (Peck et al. 1994; Great Lakes Fishery Commission, Lake Superior Committee Annual Meeting Minutes 1985-1995, unpublished). Some of the gill-net catch was from fisheries specifically for trout or salmon and some was non-target catch in fisheries for lake whitefish or other species (J.D. Shively, Great Lakes Indian Fish and Wildlife Commission, Odanah, Wisconsin, personal communication). Probably little of this catch was released alive because trout and salmon can be legally retained by tribal fishers. Non-target lake trout mortality in commercial gill nets from Wisconsin waters of Lake Superior in 1992 was determined to be 46-59% (B. Swanson, Wisconsin Department of Natural Resources, personal communication).

Perhaps the greatest concern regarding use of trap nets is catch and mortality of the common loon, a bird classified as threatened in Michigan (Michigan Loon Recovery Committee 1993). Since most sampling on most fishing grounds was done during June when loon catch was highest, the 263 killed annually in state-licensed fisheries may be an overestimate. Loons are also killed in tribal trap-net fisheries, and probably in the tribal gill-net fisheries. Annual loon mortality in tribal trap nets from Whitefish Bay, Lake Superior during 1979-1981 was established at 136-200 (Michigan Loon Recovery Committee 1993). The total number of loons killed annually in commercial fisheries in Michigan waters of Lake Superior may have exceeded 300 and possibly 400 birds during 1983-1989. If loons can escape the trap-net hearts, mortality would be reduced substantially. Carey (1992) found that increasing mesh size in the top of the hearts to 6-inch square measure (12-inch stretch measure) would allow about 80% of the loons trapped in hearts to escape, and all loons tested escaped easily through 7-inch square mesh. Carey also concluded that modifying the top of hearts with 3.3 x 3.3 ft openings should reduce loon mortality, but this modification was not tested. Such a reduction of 80% in loon catch in the hearts should reduce total loon mortality in trap nets to less than 30% of its current level, because fewer loons would reach the pot. No capture of loons and no reduction in lake whitefish catch was reported for trap nets with 6-inch square mesh in the top of the hearts fished at Marquette (Carey 1992). We recommend that MDNR establish a timetable for modification of all state-licensed trap nets to increase mesh size in the top of the hearts to 12-in or preferably 14-inch stretch-measure.

This study strongly supports MDNR's emphasis on trap nets in management of the state-licensed lake whitefish commercial fishery. In Lake Superior, trap nets efficiently harvested target species with minimal impact on non-target fishes, allowing species rehabilitation and sport fisheries to occur. Trap nets have or can be modified to overcome problems such as excessive lake trout and loon mortality. Convincing commercial gill-net fisheries for lake whitefish to convert to trap nets or other impoundment gear will be a keystone for protecting and sharing fishery resources in the Great Lakes in the future.

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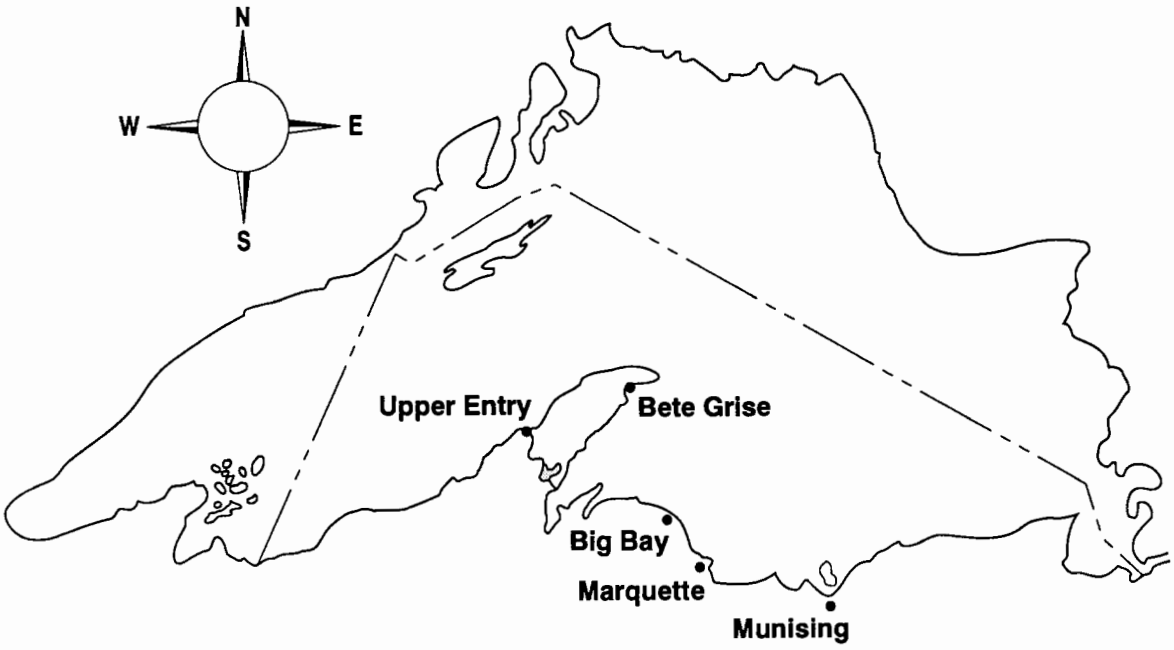

Figure 1.—Location of state-licensed commercial fisheries for lake whitefish in Michigan waters of Lake Superior, 1983-1989.

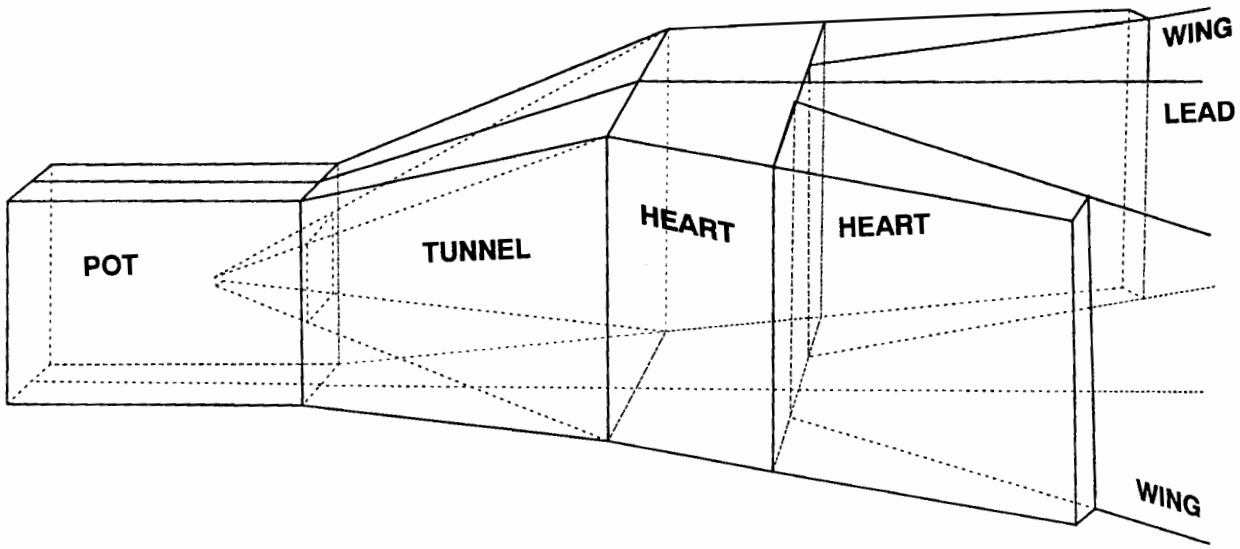

Figure 2.—Diagram of a typical Great Lakes trap net used in the lake whitefish fishery. In general, the pots are 40 feet long by 20 feet wide by 20-40 feet deep, with 100-foot long wings and a lead up to 1,000 feet long.

Table 1.—Sampling effort for non-target catch and mortality in state-licensed commercial trap nets fished in Michigan waters of Lake Superior, 1983-1989.

Fishing Ground	Year	Months Fished	Months Sampled	Days Sampled	Trap-net lifts Total	Trap-net lifts Number Sampled (percent)
Upper Entry	1983	May-Oct	May-Oct	9	546	55 (10)
	1984	May-Oct	May-Oct	11	716	76 (11)
	1985	Jun-Oct	Jun-Oct	7	440	51 (12)
	1986	Jun-Oct	Jun-Oct	7	367	54 (15)
	1987	Jul-Oct	Jul-Oct	7	234	54 (23)
	1988	Jul-Oct	Jul-Aug	4	210	30 (14)
	1989	Jun-Oct	Jun	4	277	40 (14)
	Total			49	2,790	360 (13)
Bete Grise	1985	Jun-Oct	Jul-Aug	2	238	11 (5)
	1986	Jun-Oct	Jun-Jul	4	200	22 (11)
	1987	Jun-Oct	Jul-Aug	3	114	10 (9)
	Total			9	552	43 (8)
Big Bay	1983	May-Oct	Jun-Jul	4	42	4 (10)
	1984	May-Oct	Jun-Jul	6	103	21 (20)
	1985	May-Oct	May-Jul	4	104	16 (15)
	1986	May-Oct	May-Jun	4	118	17 (14)
	1987	Apr-Oct	Jun-Jul	4	163	17 (10)
	1988	Apr-Oct	Jun	3	149	11 (7)
	1989	May-Oct	Jun-Jul	4	194	16 (8)
	Total			29	873	102 (12)
Marquette	1983	May-Oct	Jun-Aug	7	399	19 (5)
	1984	May-Oct	Jun-Jul	12	344	44 (13)
	1985	May-Oct	May-Jul	6	299	13 (4)
	1986	May-Oct	May-Jun	5	311	11 (4)
	1987	May-Oct	Jun-Jul	4	244	20 (8)
	1988	Apr-Oct	Jun	3	331	15 (4)
	1989	May-Oct	Jun-Jul	4	279	19 (7)
	Total			41	2,207	141 (6)
Munising	1983	Apr-Oct	Jun-Jul	7	536	64 (12)
	1984	May-Oct	Jun-Jul	9	644	108 (17)
	1985	May-Oct	Jun-Jul	5	680	59 (9)
	1986	May-Oct	Jun	5	674	46 (7)
	1987	Apr-Dec	Jun-Jul	4	777	37 (5)
	1988	Apr-Dec	Jun-Jul	4	747	37 (5)
	1989	Apr-Oct	Jun-Jul	2	713	15 (2)
	Total			36	4,771	366 (8)
All grounds	1983	Apr-Oct	May-Oct	27	1,523	142 (9)
	1984	May-Oct	May-Oct	38	1,807	249 (14)
	1985	May-Oct	May-Oct	24	1,761	150 (8)
	1986	May-Oct	May-Oct	25	1,670	150 (9)
	1987	Apr-Dec	Jun-Oct	22	1,532	138 (9)
	1988	Apr-Dec	Jun-Aug	14	1,437	93 (6)
	1989	Apr-Oct	Jun-Jul	14	1,463	90 (6)
	Total			164	11,193	1,012 (9)

Table 2.—Fish caught[a], gilled (number), and killed (number) per net lift for lake whitefish and lake trout, and catch per net lift for other species in the state-licensed trap-net fishery for lake whitefish on the Upper Entry fishing ground in Michigan waters of Lake Superior, 1983-1989; with ±95% confidence intervals.

Species and variable	Year (lifts sampled in parentheses) 1983 (55)	1984 (76)	1985 (51)	1986 (54)	1987 (54)	1988 (30)	1989 (40)	Mean (360)
Lake whitefish								
Legal								
Caught	902.7±375.6	347.1±106.3	390.3±135.1	328.1±103.7	331.6±96.8	60.9±30.0	65.0±25.0	377.7±71.2
Gilled	17.91±8.20	12.32±5.85	11.65±4.88	8.69±4.12	14.72±7.05	0.57±0.57	3.53±1.76	10.94±2.27
Killed	10.64±8.13	0.33±0.60	0	0.48±0.37	3.78±3.85	0.43±0.51	2.23±1.40	2.62±1.40
Sublegal[b]	15.4±7.0	14.3±7.6	40.0±19.4	19.2±10.9	9.0±8.5	26.2±25.5	1.3±1.3	17.6±4.5
Gilled	0.35±0.35	0.28±0.50	2.84±5.71	0.07±0.09	0.17±0.33	0.80±1.36	0.08±0.11	0.63±0.81
Killed	0.24±0.28	0.04±0.08	0	0.02±0.04	0	0.80±1.36	0.05±0.07	0.12±0.12
Lake trout								
Caught	15.4±4.1	10.3±3.1	6.6±2.5	7.8±2.7	5.9±1.7	9.5±3.2	10.2±3.7	9.4±1.2
Gilled	1.87±0.85	1.04±0.38	0.61±0.30	0.81±0.33	0.94±0.39	1.30±0.56	1.15±0.54	1.09±0.19
Killed	0.44±0.11	0.32±0.18	0.02±0.04	0.35±0.18	0.22±0.25	0.97±0.48	0.27±0.20	0.33±0.09
Lake sturgeon								
Caught	0.05±0.06	0.07±0.06	0.06±0.07	0.06±0.06	0	0	0.13±0.11	0.05±0.02
Coho salmon								
Caught	0.07±0.09	0	0.04±0.06	0	0	0	0.03±0.05	0.02±0.02
Chinook salmon								
Caught	0	0	0	0.02±0.04	0.02±0.04	0	0.15±0.11	0.02±0.02
Rainbow trout								
Caught	0	0	0.02±0.04	0	0	0	0.05±0.07	0.01±0.01
Brown trout								
Caught	0	0.07±0.06	0.06±0.07	0.20±0.20	0.02±0.04	0	0.30±0.21	0.09±0.04
Lake herring								
Caught	0	0	0.10±0.08	0.26±0.34	0.07±0.09	0	0.80±0.76	0.15±0.10
Round whitefish								
Caught	0.62±0.88	0	0.04±0.06	0	0	0.03±0.07	0.35±0.24	0.14±0.13
Miscellaneous[c]								
Caught	1.60±1.15	0.62±0.44	0.96±0.46	2.06±2.61	1.07±1.15	0.10±0.20	2.30±1.09	1.24±0.47
Common loon								
Caught	0.05±0.06	0.07±0.06	0.10±0.10	0.09±0.08	0	0	0.50±0.34	0.11±0.05

[a]Catch in pounds for legal whitefish, catch in numbers for non-target fish.
[b]Less than 19 inches total length in 1983-1985 and less than 17 inches total length in 1986-1989.
[c]Includes white sucker, longnose sucker, common carp, and burbot.

Table 3.—Fish caught[a], gilled (number), and killed (number) per trap-net lift of legal and sublegal lake whitefish and other species in the state-licensed commercial whitefish fishery on the Bete Grise fishing ground in Michigan waters of Lake Superior, 1985-1987; with ±95% confidence intervals.

Species and variable	Year (lifts sampled in parentheses) 1985 (11)	1986 (22)	1987 (10)	Mean (43)
Lake whitefish				
Legal				
Caught	353.0±13.9	108.8±39.9	201.2±184.9	192.8±60.7
Gilled	3.91±2.30	3.59±1.76	9.90±8.38	5.14±2.12
Killed	3.91±2.30	1.68±1.30	9.50±8.59	4.07±2.13
Sublegal[b]				
Caught	68.8±45.2	0.7±1.3	18.8±27.2	22.6±14.5
Gilled	1.45±1.79	0	1.10±1.86	0.63±0.58
Killed	1.45±1.79	0	0	0.37±0.45
Lake trout				
Caught	3.1±2.6	2.6±1.3	2.2±2.2	2.6±1.0
Gilled	0.73±0.74	0.32±0.21	0.60±0.76	0.49±0.26
Killed	0	0.14±0.16	0.50±0.77	0.19±0.21
Coho salmon				
Caught	0.09±0.20	0	0.10±0.23	0.05±0.06
Round whitefish				
Caught	0	0.05±0.09	0	0.02±0.05
Miscellaneous[c]				
Caught	0.55±0.47	0.05±0.10	0.70±0.68	0.33±0.20
Common loon				
Caught	0	0.23±0.24	0	0.12±0.12

[a]Catch in pounds for legal whitefish, catch in numbers for non-target fish.
[b]Less than 17 inches total length.
[c]Includes white sucker, longnose sucker, common carp, and burbot.

Table 4.—Fish caught[a], gilled (number), and killed (number) per trap-net lift of legal and sublegal lake whitefish and other species in the state-licensed commercial whitefish fishery on the Big Bay fishing ground in Michigan waters of Lake Superior, 1983-1989; with ±95% confidence intervals.

Species and variable	Year (lifts sampled in parentheses)							
	1983 (4)	1984 (21)	1985 (16)	1986 (17)	1987 (17)	1988 (11)	1989 (16)	Mean (102)
Lake whitefish								
Legal								
Caught	441.3±694.7	138.1±68.3	334.3±113.0	287.9±97.8	144.2±62.5	126.5±67.9	200.4±71.2	215.3±37.5
Gilled	3.75±28.62	2.48±1.64	1.75±1.08	1.47±1.09	2.41±1.31	4.27±4.38	5.69±3.65	2.93±0.85
Killed	0.50±1.59	1.19±0.88	0	0.41±0.37	1.41±1.04	3.36±4.50	2.31±1.74	1.29±0.57
Sublegal[b]								
Caught	35.3±56.1	7.6±5.1	6.19±2.32	15.4±11.9	17.4±11.0	5.3±3.4	8.1±5.0	11.2±3.6
Gilled	3.00±9.54	0.05±0.10	0.31±0.42	0.12±0.17	0.12±0.17	0	0	0.22±0.24
Killed	0	0.05±0.10	0	0	0.06±0.12	0	0	0.02±0.03
Lake trout								
Caught	14.8±35.3	5.7±2.2	5.5±2.5	10.5±4.1	1.4±1.2	4.6±3.2	5.8±3.4	6.0±1.4
Gilled	0.50±0.92	0.43±0.31	0.44±0.39	0.76±0.43	0.12±0.17	0.27±0.61	2.06±1.97	0.68±0.33
Killed	0.25±0.80	0	0.13±0.27	0.29±0.30	0	0	1.31±1.84	0.28±0.28
Lake sturgeon								
Caught	0	0.05±0.10	0.06±0.13	0.06±0.12	0.12±0.17	0.09±0.20	0.06±0.13	0.07±0.05
Brown trout								
Caught	0.50±0.92	0	0	0	0.35±0.63	0	0	0.08±0.10
Lake herring								
Caught	0.50±1.59	0	1.69±3.46	0.18±0.20	0.94±1.11	0.64±1.42	0.19±0.40	0.57±0.55
Miscellaneous[c]								
Caught	20.00±44.97	0.62±0.31	8.13±12.29	0.76±1.06	2.06±1.93	0	0.13±0.19	2.68±2.20
Common loon								
Caught	0	0.14±0.22	0	0	0.18±0.20	0	0	0.07±0.06

[a]Catch in pounds for legal whitefish, catch in numbers for non-target fish.
[b]Less than 19 inches total length in 1983-1987 and less than 17 inches total length in 1988 and 1989.
[c]Includes white sucker, longnose sucker, common carp, and burbot.

Table 5.—Fish caught[a], gilled (number), and killed (number) per trap-net lift of legal and sublegal lake whitefish and other species in the state-licensed commercial whitefish fishery on the Marquette fishing ground in Michigan waters of Lake Superior, 1983-1989; with ±95% confidence intervals.

Species and variable	Year (lifts sampled in parentheses)							
	1983 (19)	1984 (44)	1985 (13)	1986 (11)	1987 (20)	1988 (15)	1989 (19)	Mean (141)
Lake whitefish								
Legal								
Caught	221.2±78.7	145.9±43.5	220.1±91.2	258.2±91.6	135.0±24.7	218.2±184.1	49.7±32.1	164.8±28.3
Gilled	2.68±1.29	2.20±0.66	1.08±0.76	0.45±0.46	1.25±0.88	2.13±2.40	0.89±0.77	1.71±0.40
Killed	0.68±0.58	0.39±0.25	0.15±0.33	0.09±0.02	0.65±0.76	2.00±2.39	0.79±0.78	0.65±0.30
Sublegal								
Caught	4.1±3.1	1.8±0.7	6.9±5.2	1.9±1.4	5.6±3.8	4.4±2.9	1.3±1.2	3.3±0.9
Gilled	0	0.05±0.06	0	0.27±0.44	0.35±0.55	0	0	0.09±0.08
Killed	0	0.02±0.05	0	0	0.10±0.21	0	0	0.02±0.03
Lake trout								
Caught	10.4±4.6	15.3±3.4	28.5±18.0	11.9±4.9	5.4±2.2	4.3±2.9	3.3±3.1	11.4±2.3
Gilled	1.37±0.67	1.75±0.59	1.77±1.31	0.82±0.84	1.35±0.90	0.13±0.29	0.53±0.79	1.23±0.29
Killed	0.11±0.15	0.43±0.27	0.23±0.36	0	0.70±0.63	0	0.53±0.79	0.34±0.16
Lake sturgeon								
Caught	0	0	0	0	0.05±0.10	0	0.11±0.22	0.02±0.03
Brown trout								
Caught	0	0	0	0	0.10±0.21	0	0	0.01±0.03
Miscellaneous[b]								
Caught	3.47±6.64	0.39±0.32	8.85±13.04	0.27±0.60	6.20±10.41	0.53±0.51	0.21±0.25	2.39±1.98
Common loon								
Caught	0	0.16±0.13	0.23±0.36	0	0.20±0.19	0	0	0.10±0.06

[a]Catch in pounds for legal whitefish, catch in numbers for non-target fish.
[b]Includes white sucker, longnose sucker, common carp, and burbot.

Table 6.—Fish caught[a], gilled (number), and killed (number) per trap-net lift of legal and sublegal lake whitefish and other species in the state-licensed commercial whitefish fishery on the Munising fishing grounds in Michigan waters of Lake Superior, 1983-1989; with ±95% confidence intervals.

Species and variable	Year (lifts sampled in parentheses)							
	1983 (64)	1984 (108)	1985 (59)	1986 (46)	1987 (37)	1988 (37)	1989 (15)	Mean (366)
Lake whitefish								
Legal								
Caught	186.0±41.5	123.6±16.0	229.5±39.7	175.6±32.7	217.8±67.6	87.4±22.0	251.9±75.0	169.2±14.4
Gilled	3.16±0.90	2.17±0.47	3.68±1.00	2.09±1.08	4.41±1.83	1.22±0.46	6.60±3.73	2.89±0.39
Killed	0.63±0.54	0.04±0.04	0.03±0.07	1.28±0.83	2.81±1.21	0.32±0.29	6.33±3.83	0.86±0.27
Sublegal								
Caught	17.0±8.1	4.0±1.9	14.1±7.8	6.6±6.1	8.1±5.6	8.4±3.8	8.6±2.5	9.3±2.2
Gilled	0.48±0.44	0	0	0	0	0	0	0.08±0.08
Killed	0.03±0.04	0	0	0	0	0	0	0.01±0.01
Lake trout								
Caught	4.7±1.4	4.5±0.7	5.7±1.4	5.2±1.9	2.4±1.1	3.0±1.6	0.3±0.3	4.3±0.5
Gilled	0.69±0.32	0.52±0.18	0.66±0.32	0.28±0.17	0.32±0.35	0.43±0.30	0	0.49±0.11
Killed	0.23±0.23	0.20±0.10	0	0.04±0.06	0.27±0.30	0.27±0.20	0	0.16±0.06
Lake sturgeon								
Caught	0	0	0.05±0.06	0.04±0.06	0	0.03±0.05	0	0.02±0.01
Coho salmon								
Caught	0.06±0.06	0	0.07±0.08	0	0.08±0.12	0	0	0.03±0.02
Chinook salmon								
Caught	0	0	0.02±0.04	0	0.03±0.05	0.03±0.05	0	0.01±0.01
Rainbow trout								
Caught	0.02±0.03	0.03±0.03	0.02±0.03	0	0	0	0	0.01±0.01
Brown trout								
Caught	0.02±0.03	0	0.02±0.03	0.02±0.04	0.03±0.05	0	0	0.01±0.01
Lake herring								
Caught	0.05±0.05	0	0	0.04±0.09	0	0.19±0.38	0	0.03±0.04
Round whitefish								
Caught	0	0	0	0.04±0.09	0	0	0	0.01±0.01
Miscellaneous[b]								
Caught	1.67±1.08	1.82±0.81	2.53±1.62	0.37±0.26	0.73±0.79	0.92±0.55	0.20±0.24	1.46±0.41
Common loon								
Caught	0.53±0.25	0.19±0.09	0.10±0.10	0.24±0.17	0.08±0.09	0.22±0.14	0.07±0.14	0.23±0.06

[a]Catch in pounds for legal whitefish, catch in numbers for non-target fish.
[b]Includes white sucker, longnose sucker, common carp, and burbot.

Table 7.—Fish caught[a], gilled (number), and killed (number) per trap-net lift of legal and sublegal lake whitefish and other species in the state-licensed commercial whitefish fishery in all Michigan waters of Lake Superior, 1983-1989; with ±95% confidence intervals.

Species and variable	Year (lifts sampled in parentheses)							
	1983 (142)	1984 (249)	1985 (150)	1986 (150)	1987 (138)	1988 (93)	1989 (90)	Mean (1,012)
Lake whitefish								
Legal								
Caught	475.2±155.3	197.0±36.2	303.6±51.4	239.5±42.2	240.1±45.2	104.6±32.5	117.2±26.5	248.4±27.0
Gilled	8.82±3.37	5.30±1.87	5.97±1.86	4.49±1.60	8.14±2.95	1.52±0.66	3.87±1.20	5.69±0.86
Killed	4.51±3.19	0.29±0.20	0.31±0.22	0.87±0.34	3.19±1.64	0.99±0.64	2.62±0.97	1.64±0.52
Sublegal								
Caught	15.2±4.8	7.0±2.5	25.5±8.2	10.9±4.6	10.0±4.2	13.1±8.3	3.7±1.3	12.2±1.9
Gilled	0.44±0.28	0.10±0.16	1.11±1.92	0.06±0.04	0.21±0.20	0.26±0.44	0.03±0.05	0.31±0.29
Killed	0.11±0.12	0.02±0.02	0.11±0.12	0.01±0.02	0.02±0.04	0.26±0.44	0.02±0.03	0.07±0.05
Lake trout								
Caught	9.84±2.02	8.22±1.28	7.76±2.00	6.83±1.31	4.07±0.87	5.52±1.41	6.29±1.98	7.19±0.61
Gilled	1.23±0.38	0.89±0.18	0.72±0.20	0.57±0.16	0.71±0.24	0.65±0.24	0.99±0.45	0.83±0.10
Killed	0.30±0.16	0.26±0.08	0.04±0.04	0.15±0.08	0.35±0.16	0.42±0.18	0.47±0.36	0.26±0.05
Lake sturgeon								
Caught	0.02±0.02	0.02±0.02	0.05±0.04	0.04±0.04	0.02±0.02	0.02±0.03	0.09±0.07	0.03±0.01
Coho salmon								
Caught	0.06±0.04	0	0.05±0.04	0	0.03±0.04	0	0.01±0.02	0.02±0.02
Chinook salmon								
Caught	0	0	0.01±0.02	0.01±0.02	0.01±0.02	0.01±0.02	0.07±0.05	0.01±0.01
Rainbow trout								
Caught	0.01±0.02	0.01±0.02	0.01±0.02	0	0	0	0.02±0.03	0.01±0.01
Brown trout								
Caught	0.02±0.02	0.02±0.02	0.03±0.02	0.08±0.08	0.07±0.08	0	0.13±0.09	0.05±0.02
Lake herring								
Caught	0.04±0.04	0	0.21±0.34	0.13±0.12	0.14±0.14	0.15±0.22	0.39±0.35	0.12±0.07
Round whitefish								
Caught	0.24±0.34	0	0.01±0.02	0.02±0.02	0	0.01±0.02	0.16±0.11	0.05±0.05
Miscellaneous[b]								
Caught	2.39±1.35	1.10±0.39	2.99±1.72	0.97±0.93	1.82±1.52	0.48±0.24	1.12±0.54	1.59±0.41
Common loon								
Caught	0.26±0.12	0.14±0.06	0.09±0.06	0.14±0.06	0.07±0.04	0.10±0.06	0.23±0.16	0.15±0.03

[a]Catch in pounds for legal whitefish, catch in numbers for non-target fish.
[b]Includes white sucker, longnose sucker, common carp, and burbot.

Table 8.—Estimated number of non-target species caught and killed annually (mean ±95% confidence interval) in state-licensed commercial trap-net fisheries for lake whitefish in Michigan waters of Lake Superior; with ±95% confidence intervals.

Species and variable	Fishing ground (mean number of nets lifted annually in parentheses)				
	Upper Entry (399)	Bete Grise (184)	Big Bay (110)	Marquette (315)	Munising (682)
Whitefish					
Sublegal					
Caught	7,022±1,796	4,232±2,760	1,210±440	946±315	6,311±1,520
Killed	48±48	68±83	2±3	6±9	7±7
Lake trout					
Caught	3,751±479	552±184	660±110	3,468±631	2,910±341
Killed	132±36	35±39	31±31	107±50	109±41
Lake sturgeon					
Caught	20±8	0	8±6	6±9	14±7
Killed[b]	0		0	0	0
Coho salmon					
Caught	8±8	9±11	0	0	20±14
Killed[b]	6	6			14
Chinook salmon					
Caught	8±8	0	0	0	7±7
Killed[b]	3				3
Rainbow trout					
Caught	4±4	0	0	0	7±7
Killed[b]	2				4
Brown trout					
Caught	36±16	0	9±11	3±9	7±7
Killed[b]	8		2	0	2
Lake herring					
Caught	60±40	0	63±61	0	20±27
Killed[b]	17		18		6
Round whitefish					
Caught	56±52	4±11	0	0	7±7
Killed[b]	33	2			4
Miscellaneous[a]					
Caught	495±188	52±35	294±242	750±624	968±279
Killed[b]	4	1	2	0	8
Common loon					
Caught	44±20	22±22	8±6	32±19	157±41
Killed	44±20	22±22	8±6	32±19	157±41

[a]Includes white sucker, longnose sucker, common carp, and burbot.

[b]Number killed based on percentage observed mortality applied to total catch and confidence intervals not determined.

Table 9.—Number of lake trout caught, gilled, and killed per trap-net lift by month in the state-licensed trap-net fishery for lake whitefish on the Upper Entry fishing ground in Michigan waters of Lake Superior, 1983 and 1984.

Year and month	Commercial fishery[a]		Sampled net lifts			
	Net lifts	Number per net lift	Net lifts	Number per net lift		
				Caught	Gilled	Killed[b]
1983						
May	45	23±3	3	31±27	3.6±5.2	—
Jun	152	9±1	17	10±5	0.9±0.7	—
Jul	101	11±1	6	10±10	1.8±1.4	—
Aug	102	12±2	13	25±13	4.2±2.2	0.22±0.12
Sep	41	8±2	4	23±30	2.1±2.7	1.50±1.95
Oct	106	5±1	12	8±4	0.4±0.2	0.42±0.21
Total	547	10±1	55	15±4	1.9±0.5	0.43±0.11
1984						
May	77	18±1	8	22±20	1.5±1.4	0
Jun	168	11±1	20	19±6	2.0±0.7	0.26±0.09
Jul	111	4±1	13	4±3	0.8±0.6	0.58±0.44
Aug	185	5±1	9	2±2	0.1±0.1	0
Sep	91	5±1	15	5±3	0.8±0.8	0.33±0.33
Oct	84	4±1	11	8±5	0.7±0.4	0.55±0.34
Total	716	8±1	76	10±4	1.0±0.4	0.32±0.18

[a]Reported by the commercial fishery.
[b]Number killed per trap-net lift not determined for May-Jul 1983.

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