# 2009 SPAWNING CISCO INVESTIGATIONS IN THE CANADIAN WATERS OF LAKE SUPERIOR

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**Abstract**

We sampled with acoustics (AC) and midwater trawls (MT) to determine cisco abundance in Lake Superior's Thunder and Black bays during 8-14 November, 2009. Total abundance of spawning-size (≥ 250 mm total length) ciscoes was estimated at 6.25 million in Thunder Bay and 1.12 million in Black Bay. Exploitation fractions of market-size (≥ age 6) females from Thunder and Black bays for 2009 were estimated at 7.1% and 11.3%, respectively; below the recommended maximum annual harvest of 15% recently adopted by Lake Superior fisheries managers. Given Thunder Bay spawner densities are on a downward trajectory, and recruitment since the 2003 year-class has been low, it is likely the exploitation fractions will increase in the future. After 2010, the Ontario Ministry of Natural Resources (OMNR) will carry on the AC program as a management activity. It is likely suspended experimental gill net (GN) samples will be used to ground truth future AC samples. In 2009, we characterized the length and age structure of Thunder Bay ciscoes using both MT samples and GN samples. Females represented 49% of the MT catch, but only 39% in GN samples. Catching a smaller proportion of females in GN samples resulted in a lower female population estimate and a higher estimated exploitation fraction (10.4%) compared to MT samples (7.1%). Experimental gill net effort was limited to 10-11.8 m water column depths where midwater trawl samples also caught roughly 40% females. Ciscoes ≥ age 17 (≥ 1992 year class) were common in Black Bay, but rare in Thunder Bay suggesting: 1) the stocks may be distinct; and 2) total mortality of ciscoes returning to spawn in Black Bay in recent years has been lower than ciscoes returning to Thunder Bay. Our mid-November 2009 effort to assess the Black Bay stock by sampling outside of the

bay in the lake proper was deemed successful, but this should be confirmed by sampling the Black Bay region during both mid- and late-November 2010.

## Introduction

Controlling harvest to promote population persistence is a critical fisheries management activity. Coregonid species in oligotrophic systems are typically long lived (Aass 1972; Mills and Beamish 1980; Yule et al. 2008); an adaptation to survival where conditions for reproductive success can be variable. It is not uncommon for the bulk of coregonid biomass in these systems to be composed of adults which devote most of their net production to gamete formation. High gamete output coupled with ideal post-spawn conditions can lead to a strong year-class, with longevity a means to overcome several straight years of poor recruitment conditions. Fisheries should be managed so harvest does not reduce the targeted population's ability to maximize recruitment when conditions are ideal for high juvenile survival.

Ciscoes *Coregonus artedi* can live to be over age 20 in Lake Superior (Yule et al. 2008). As juveniles they serve as prey of native lake trout *Salvelinus namaycush* (Ray et al. 2007), and there is growing evidence that cisco eggs cast in early December may be an important overwinter energy subsidy to benthic fishes like lake whitefish *Coregonus clupeaformis* [United States Geological Survey, Great Lakes Science Center, Lake Superior Biological Station (LSBS), Ashland, WI, unpublished data]. Several Lake Superior cisco stocks are fished with most harvest occurring during November when ciscoes form pre-spawning aggregations in coastal areas. Fishers target females for their roe by suspending large mesh gill nets (> 80 mm stretch measure) just below the surface. Most of the roe is sold abroad. Management agencies comprising the Lake Superior Technical Committee recently recommended an annual harvest level of no more than 10-15% of adult females (Stockwell et al. 2009). Exploitation fractions have been estimated by dividing estimates of numbers harvested by estimates of abundance from November fishery-independent acoustic and midwater trawling (AC-MT) surveys (Yule et al. 2006; 2008). Allowable harvest fractions were set low because managers recognize the important role ciscoes fill in the Lake Superior ecosystem (Stockwell et al. 2009).

Thunder and Black bays of Canada support the two largest Lake Superior roe fisheries (Ebener et al. 2008). Harvest is regulated by the Ontario Ministry of Natural Resources (OMNR) by setting total allowable catch (TAC) quotas. During the 2009 roe fishery, the Thunder and Black bay TACs were set at 180,502 kg and 121,845 kg, respectively. Beginning in 2007, the OMNR – Upper Great Lakes Management Unit (UGLMU) and LSBS initiated a 3-year study to develop standard operating procedures (SOPs) for assessing cisco spawner abundance in these bays. This report describes year three findings. A study completion report describing SOPs should be finalized during 2011.

To date, MT samples collected with the LSBS research vessel (R/V) *Kiyi* have been used to ground truth study AC data. Since we recently learned the UGLMU R/V *Everett H.* can not be retrofitted to midwater trawl, gillnetting seems the most viable option for ground truth collections in the future. During November 2009, we collected data to explore how using gill nets and MT gear affected metrics like female abundance and exploitation fractions.

We address four study objectives:

1) Measure and map densities of spawning-size (≥ 250 mm total length, TL) ciscoes and rainbow smelt *Osmerus mordax* in Thunder and Black bays.

2) Combine results of a fishery-independent survey and commercial harvest information to estimate exploitation fractions in Thunder and Black bays.

3) Determine how exploitation fractions of Thunder Bay ciscoes vary depending on whether midwater trawl or multi-mesh gill net samples are used to estimate cisco age distributions.

4) Use results of recent (2005-2009) surveys to explore the sustainability of total allowable catch (TAC) quotas of both bays.

## Methods

*Fishery-independent survey*

We sampled pelagic fish populations in both bays during the nighttime hours of 8-14 November 2009 using a systematic grid survey design (Figure 1). Previous analyses of commercial gill net lifts suggested that ciscoes typically move into Thunder Bay in early November and form spawning aggregations, while ciscoes arrive in Black Bay in late November (Yule et al. 2009a). The bay where the R/V *Kiyi* winters normally freezes over before late November, so we opted to sample both Black Bay (management zone 7, Figure 1) and outside of Black Bay in the lake proper (management zones 6 and 9) during mid November. Estimates of fish abundance we report for Thunder Bay were based on samples collected in management zones 1-4; estimates for Black Bay were based on samples collected in zones 6, 7 and 9.

Acoustic data were collected continuously along the survey path using a 123 kHz split-beam transducer with a half-power beam width of 6.8$^{o}$ deployed to a water depth of 2.3 m through a vessel sonar tube. Sampling occurred at night because ciscoes school during daylight and disperse at night (Milne et al. 2005), thus improving our ability to sample their populations (Yule et al. 2007). We sampled at a ping rate of 3-6 pings per second while traveling at 8-10 knots/hour (2-3 knots/hour while midwater trawling). Acoustic data were collected following recommendations in the new acoustic Great Lakes SOP (GLSOP; Rudstam et al. 2009). Mark thresholds were set at -100 decibels (dB) for standard sphere calibration and data collection, and -130 dB for passive noise collections.

Pelagic fish were sampled using both MT gear and by gill nets. The midwater trawl had 15.2 m head rope and foot rope, and 13.7 m breast lines with cod-end mesh of 13 mm (all meshes are square measure). A total of 23 MT samples were periodically collected during acoustic sampling (Figure 1). Trawls were fished at fixed depths with each sample 20 minutes in duration. Trawl depth and wingspread (i.e., trawl width while fishing) were monitored in real time with a trawl mensuration system, with data recorded at roughly 10-s intervals.

We fished a single 152.5-m x 1.8 m multi-mesh gillnet comprised of five 30.5 m panels of 51-, 64-, 76-, 89-, and 102-mm mesh over five different nights (Figure 1). The gill net was fished at a depth 10 m below the surface using floats and lines attached at 8 m intervals along the net length. The gill net was set after dark and retrieved the same night after fishing 5.5-7.5 hours.

Captured fish were sorted to species, counted, weighed in aggregate to the nearest gram, placed in labeled plastic bags and iced. Samples were processed further the next morning at the UGLMU lab (Thunder Bay, Ontario). Up to 100 rainbow smelt per trawl sample were selected randomly and measured to the nearest mm (other species were not sub-sampled). Ciscoes ≥ 150 mm TL were assigned a unique tracking number, measured to the nearest mm, weighed to nearest gram, dissected to determine sex and maturity state and otoliths were removed to estimate their age. Ciscoes < 150 mm were assumed to be age 0. Few ciscoes of this size could not be reliably sexed, so we assumed 50:50 sex ratio when reporting their abundance. Individual weights of other species were estimated using length-weight regressions developed from Lake Superior fishes (Gamble et al. MS submitted).

Acoustic data processing followed the GLSOP using Echoview Software version 4.5 (Myriax Pty. Ltd., Hobart, Tasmania, Australia). Bottom lines generated with the software bottom tracking algorithm after applying a 0.5 m offset were examined and corrected manually. Surface lines were added at 4.1 m (i.e., 2.3 m transducer depth + 2 x transducer near field of 0.9 m). We applied -55 decibel (dB) and -61 dB thresholds to target strength (TS) and volume backscattering strength (S*v*) echograms, respectively, with the later threshold being a range-dependent threshold (Rudstam et al. 2009). We used single target criteria recommended in the GLSOP (Rudstam et al. 2009). The passive noise test was used to estimate the S*v* noise level at 1 m (i.e., $Sv_{n,1}$ = -122.1 dB) and this noise was removed. From $Sv_{n,1}$ we calculated $TS_{n,1}$ at -144.2 dB). Based on this ambient noise level, we could detect a -55 dB fish target (smallest target of interest) down to a range of 69 m (73.1 m depth) while maintaining the recommended signal to noise ratio of 15 dB (i.e., $TS_{n,69} < -70$ dB) recommended by Rudstam et al. 2009.

Echograms were overlaid with 2 km by 20 m high cells and total fish density in each cell was estimated using the echo integration method. Acoustic data above the surface line and below the bottom line were excluded. Fish density was calculated by:

$$\text{Fish density (number/ha)} = ABC/\sigma_{bs} \times 10{,}000,$$

where ABC is the area backscattering coefficient (ABC = $10^{Sv/10}$ x mean thickness of the cell being integrated in m), $\sigma_{bs}$ is the average backscattering cross section of the average detected single fish targets calculated from mean TS ($\sigma_{bs} = 10^{TS/10}$), and 10,000 is $m^2$ per hectare. Target strength distributions from each cell were used to calculate the proportion of targets < and ≥ -35.6 dB and total fish density was multiplied by these proportions to estimate densities of small and large fish per cell. This approach was used previously to separate Lake Superior pelagic fish to species with spawning-size ciscoes typically the only species returning echoes > -35.6 dB (Yule et al. 2006; 2009b). In terms of actual fish size, -35.6 dB is analogous to a 250 mm cisco (Rudstam et al. 1987; Mehner 2006).

Acoustic and midwater trawling results were combined to estimate species density and biomass (kg/ha) estimates following the methods of Yule et al. (2009b). Acoustic density of small and large fish were summed across vertical cells in each 2-km interval, and intervals were "linked" to the nearest midwater trawl sample using a Geographic Information System (GIS). Interval estimates of small and large fish were apportioned to species based on nearest trawl samples regardless of trawl depth. Species biomass (kg/ha) was calculated by multiplying species density by the mean weight of that species in the nearest trawl sample. Average density and biomass of each species were calculated using the interval estimates as sampling units. Confidence bounds were developed with a bootstrap. During each bootstrap iteration, interval density estimates of small and large fish were resampled with replacement until the number of actual intervals collected was met. When an interval was sampled so was its nearest trawl sample. The numbers of small fish and large fish caught in each nearest trawl were resampled with replacement and species proportions and average weights were recalculated to estimate density and biomass of each species along each interval. A total of 1,000 bootstrap iterations were conducted and mean density and biomass of each species were calculated each iteration. We estimated 95%

confidence intervals for each species density and biomass from the distribution of 1,000 estimates using the methods of Manly (1997). Abundance (millions of fish) and total biomass (metric tons) were calculated by multiplying mean density and biomass estimates by the estimated areas of Thunder Bay (Zones 1-4 = 77,749 ha) and Black Bay (50,604 ha) we sampled.

To map spatial distributions of rainbow smelt and spawning-size cisco, we imported AC-MT density estimates measured along the 2-km intervals into ArcMap GIS. Densities at un-sampled locations were predicted using ordinary kriging using a geostatistical analyst extension. The optimal theoretical semivariogram model (i.e., nugget, sill and range) was developed from the experimental variogram by the GIS extension. Nearest neighbors were found using a circular search area comprised of four $90^{o}$ sectors. A maximum of five and a minimum of two neighbors in each sector were used along with the theoretical variogram to predict densities at un-sampled locations.

*Commercial catch data*

Yield by management zone was estimated from commercial lift records. Each license holder was required to save the first 10 ciscoes from each lift (hereafter net run ciscoes) which were collected daily by OMNR for processing. Each net run cisco was assigned a tracking number, measured, weighed, dissected for sex and maturity state, otoliths were removed for age estimation and records were entered in a database (hereafter, net run database). Net run ciscoes collected over the course of the roe fishery were assumed to be representative of the entire catch. Yield from each management zone was apportioned to sex based on proportions of males and females (by total weight) in the net run database.

Numbers of males and females harvested by zone were estimated by dividing biomass of each sex harvested by the mean weight of each sex in the net run database.

*Development and application of age-length keys*

Ciscoes were aged from otoliths using the crack-and-burn method of Schreiner and Schram (2001) by Jon Tost (North Shore Environmental Services, Thunder Bay, Ontario). Owing to large sample sizes, only a subsample of net run and those caught by midwater trawling from Thunder Bay were aged. Specimens for ageing were sampled randomly, and once aged, were used to develop age-length keys for each sex compiled with 10-mm length bins. All ciscoes caught in experimental gill net samples were aged. Age-length keys were developed for commercially harvested males and females from Thunder (zones 1-3 pooled; no fishing occurred in zone 4) and Black bays (zones 6, 7 and 9 pooled). Keys were also developed for ciscoes collected in the fishery-independent samples (i.e., keys for both sexes caught in MT samples from each bay, and male and female keys caught by experimental gillnetting from Thunder Bay only). We assumed the age keys developed from net run fish represented the commercial catch and each aged fish was weighted to the total catch on a per sex basis. We first applied MT keys to length distributions of males and females caught in this gear. We then expanded the estimated age distributions of trawl-caught ciscoes to the estimated numbers of males and females ciscoes at-large in each bay from the AC-MT survey. Because only large fish were caught in experimental gillnets, keys developed from these data were applied differently. The abundance of all large fish from the AC survey was apportioned to species first (based on proportions caught), then to males and female ciscoes based on their relative catch in experimental gillnets. Male and female abundance estimates were then apportioned to year classes assuming the sizes and ages of each sex caught in experimental gill nets represented the population at-large.

*Exploitation fractions*

Estimates of the numbers of each year class at-large and those harvested were summed over the 10-mm length bins. We then summed fish belonging to three age-class groupings (≤ age 5, age 6 to 12 and ≥ age 13). We defined market-size fish as ≥ age 6. Exploitation fractions were calculated by dividing the number harvested by the number at-large (expressed as a percentage).

## Results

*Fishery-independent survey*

Rainbow smelt were predominant in MT catches from Black Bay representing 94.23% of the catch there (Table 1; Figure 2), while rainbow smelt (48.36%) and ciscoes (45.75%) made up most of the MT catch from Thunder Bay. Sampling during 2007-2008 had produced no new cisco recruits (Figure 3), but in 2009 we caught 22 age 0 ciscoes (< 150 mm) from Thunder Bay (Figure 3) and 8 from Black Bay (data not shown). Age 0 chubs (species could not be reliably identified) were also caught from both bays. Age 0 chubs could be discerned from age 0 ciscoes on the basis of their smaller body size and the length of their pelvic fins. The largest cisco catches in MT samples occurred west of the City of Thunder Bay (Figure 2). Ciscoes were not caught in the two tows conducted in Black Bay, but were caught in the four midwater trawl samples collected south of Black Bay (Figure 2). Ciscoes represented nearly the entire catch in the multi-mesh experimental gill nets from both study sites (Table 2).

The sex ratio of large (≥ 250 mm TL) ciscoes caught in MT samples from Thunder Bay was nearly 50:50 (51% males, 49% females). The ranges of male and female lengths caught there in 2009 were similar to those caught in 2008 (Figure 3). The catch of age 0 ciscoes (< 150 mm), albeit few, was the most we had collected in MT samples since 2005 (Figure 3). Males were more common in experimental gillnets catches from Thunder Bay (males = 190 caught, 61%; females = 122, 39%). Of the 137 ciscoes caught from Black Bay in MT that we could reliably sex, females represented 58%.

The ranges of cisco lengths caught in the two gears were similar (Figure 4). The modal length of females (363 mm) caught in MT samples was slightly larger than the modal length of males (338 mm), while the length distributions of males and females caught in experimental gill nets were similar in shape. The most notable difference between the two gears is that gillnets generally caught a greater proportion of males compared to MT samples (Figure 4).

The catch of ciscoes in MT samples from Thunder Bay was highest in the upper water column and declined with depth (Figure 5). We tested if sex ratio varied systematically by head rope depth by fitting a linear regression line to a bivariate plot of proportion female (y-axis) against trawl head rope depth (x-axis). The resulting equation was proportion female = 0.509 - 0.000354 x head rope depth (m). The slope of this best-fit line did not vary significantly from zero ($P = 0.84$), evidence sex ratio did not vary systematically with depth. Three trawl samples had sex ratios that varied significantly from 50:50. One near-surface trawl (head rope = 2.8 m, Figure 5) had a sex ratio of 55.7 females: 44.3 males ($N = 174$ total ciscoes caught) which varied significantly from 50:50 ($P = 0.02$). Two trawl samples having more males also varied significantly from a 50:50

sex ratio. One with a head rope depth of 8.8 m caught 58 males (59.8%) and 39 females (40.2%) which varied significantly from 50:50 (P = 0.01), while another fished at 15.7 m head rope depth caught 36 males (62.1%) and 22 females (37.9%, P = 0.02). Males represented 61% of the catch in experimental gillnets fished between 10-11.8 m depth in Thunder Bay. Both the trawl and gillnet catches suggest males outnumbered females at the intermediate depths sampled (i.e., ≈8-15 m).

Like the MT results, the majority of large (≥ -35.6 dB) acoustic targets were found in the upper water column above 40 m depth (Figure 6). Small and large acoustic targets were similar in number at 4.1-20 m in Thunder Bay, with smaller targets more common than large targets from 20-40 m (Figure 6). Large targets were generally deeper (20-40 m) in zones 6 and 9 with fewer large targets above 20-m depth. Large targets were nearly absent between 0-40 m in Black Bay proper (zone 7).

Rainbow smelt densities were lowest (< 500/ha) in management zones 6 and 9, moderate in Thunder Bay, and highest in Black Bay (zone 7) where rainbow smelt densities > 5,000/ha were common (Figure 7). The highest spawning-size cisco densities were measured in Thunder Bay, east by northeast of the City of Thunder Bay (Figure 7). Another high spawner aggregation was measured on the east side of Thunder Bay (Figure 7).

Average density of rainbow smelt in the Thunder and Black bay study areas were estimated at 849.5/ha and 1,617.6/ha, respectively (Table 3). Mean biomass levels of rainbow smelt were similar across bays (Thunder Bay = 7.57 kg/ha; Black Bay = 7.42 kg/ha; Table 4). We estimate that Thunder Bay supported 66.05 million rainbow smelt

(Table 5) collectively weighing 588.6 metric tons (Table 6); Black Bay an estimated 81.86 million rainbow smelt weighing 375.5 metric tons.

Average density of spawning-size ciscoes (males + females) in the Thunder and Black bay study areas were estimated at 80.5/ha and 32.2/ha, respectively (Table 3). Biomass levels were 2.5 times higher in Thunder Bay (25.95 kg/ha) compared to Black Bay (10.7 kg/ha). We estimate Thunder Bay supported 6.25 million spawning-size ciscoes (3.09 million males and 3.16 million females; Table 5), while Black Bay supported 1.63 million (0.51 million males and 1.12 million females). Total biomass of spawning size ciscoes was estimated at 2,017.6 metric tons in Thunder Bay and 541.5 metric tons in Black Bay.

As individuals from the 2003 cisco year-class grew to adult size, we saw an increase in average spawner densities in Thunder Bay from 2005 to 2007 (Figure 8). Since 2007, spawning cisco densities in Thunder Bay have been tracking downwards (Figure 8) which is consistent with low recruitment after 2003 and the population succumbing to both fishing and natural mortality. The density of spawners measured in November 2009 was similar to the level measured during November 2005.

*Trawl-caught cisco ages*

A total of 1,003 ciscoes caught in MT samples from Thunder Bay were aged. Males from the 2003 year-class (age 6) representing 71.1% of 515 males aged (Appendix A), followed by age 11 (1998 year class; 12.0%) and age 4 (2005 year-class; 8.5%). Of the 488 females aged (Appendix B), age 6 were predominant (79.1%), followed by age 11 (10.7%) and age 21 (1988 year-class; 4.3%). Old (≥ age 17) males and females represented 0.4% and 5.1% of the number of Thunder Bay males and females aged, respectively.

Owing to lower catches, fewer ciscoes caught by midwater trawling from Black Bay were aged (63 males; 87 females). In general, ciscoes captured in Black Bay were older then Thunder Bay ciscoes. Males were predominantly age 6 (38.1%) and age 11 (36.5%). Males ≥ age 17 representing 9.5% of the males aged (Appendix C). Black Bay females were predominantly age 6 (39.1%), age-11 (24.1%), with age-17 and older females represented 24.1% of the females aged (Appendix D).

A total of 179 males and 114 females caught in experimental gillnets from Thunder Bay were aged. Like with ciscoes caught in MT samples there, males and females caught in experimental gillnets were mostly age 6 (males = 68.2%, Appendix E; females = 71.1%, Appendix F) and age 11 (males = 14.5%; females =11.4%).

We applied the MT caught age-length keys to AC-MT estimates of males and females at-large in Thunder Bay (Figure 9). Abundance estimates of each year class have declined over the time series. The old ciscoes from the 1987-1991 year-classes, present in 2005 and 2007, have seemingly been lost to senescence. Data in Figure 9 were arranged to show abundance estimates of different ages over time (Figure 10).

The distributions of different ages at-large in Thunder Bay developed from midwater trawl and experimental gillnet catches (Figure 11) were similar in that 4 year classes (1998, 2002, 2003 and 2005) were predominant in both gear types. Abundance estimates of females belonging to the 1998 and 2003 year classes were lower than males using the gillnet catches. This result was driven by the greater catch of males relative to females in experimental gillnet samples. Differences in the estimated numbers of males and females belonging to the 1998 and 2003 year classes were comparatively small when MT samples were used to apportion AC-MT estimates of cisco abundance (Figure 11).

*Commercial catch data*

Commercial fishers harvested an estimated 159,594 kg and 100,142 kg of ciscoes from Thunder (∑ of zones 1-3) and Black (∑ of zones 6, 7 and 9) bays, respectively (Table 7). An estimated 255,071 females were harvested from Thunder Bay (64.61% of the catch) compared to 139,740 males. Females represented 67.42% of the estimated 205,231 ciscoes harvested from Black Bay (Table 7).

We aged 637 ciscoes harvested from Thunder Bay during 2009. Of this total, 207 males (Appendix G) and 430 females (Appendix H) were aged. The age distribution of ciscoes harvested from Thunder Bay has changed markedly in recent years. During 2005, females from the 1987-1990 and 1998 year-classes made up the bulk of the commercial catch (Figure 12). Beginning in 2007, the 2003 year-class became dominant in the Thunder Bay fishery. Since 2007, the relative contribution of the 2003 year-class has increased, the 1998 year-class contribution has decreased, and the 1987-1991 year-classes have become rare in the catch (Figure 12). Data in Figure 12 were arranged to show estimates of the numbers of different ages harvested over time (Figure 13).

A total of 864 ciscoes harvested from Black Bay in 2009 were aged (305 males, Appendix I; 559 females, Appendix J). The age composition of the ciscoes harvested from Black Bay in 2009 differed from Thunder Bay from the standpoint that fish from the 1987-1991 year-classes were represented (Figure 14). Ciscoes from the 1998 year-class also represented a larger proportion of the catch in Black Bay (Figure 14) relative to Thunder Bay (Figure 12). The composition of different age classes harvested from Black Bay was similar to the composition at-large estimated by ageing fish caught in MT samples (Figure 14).

The U.S. Geological Survey, Lake Superior Biological Station, conducts an annual lake-wide fish community survey each spring in Lake Superior (see Stockwell et al. 2007 for details). Results of this day bottom trawl survey are used to index cisco year-class strength based on the estimated average densities of age 1 ciscoes caught. The same strong cisco year -classes (1988-1990, 1998, 2003) present in our recent November spawner surveys coincide with strong year-classes indexed by the annual fish community survey (Figure 15).

*Exploitation fractions*

The estimated exploitation fractions during 2009 were higher for females than males for all three Thunder Bay age-class groupings (Figure 16). Using 2009 estimates, exploitation for female age groupings were 1.1% for ages 0-5, 6.9% for ages 6-12 and 9.7% for ≥ age 13 and older. For males, 2009 exploitation fractions were estimated at 0.5% for ages 0-5, 3.9% for ages 6-12, and 3.3% for ≥ age 13. We calculated an average exploitation fraction for each combination of sex and age-class grouping using data from 2007-2009 (Figure 16), and all average values fell below 8% (Figure 16). The estimated exploitation fraction of market-size females (≥ age 6) was 7.1% in 2009.

Estimated exploitation fractions from Black Bay were generally higher than Thunder Bay estimates (Figure 17). Exploitation rates of females from Black Bay were estimated at 9.3% for age 0-5 females, 12.4% for age 6-12 females, and 8.2% for females ≥ age 13. Exploitation rates of males were estimated at 3.9% for ages 0-5, 13.8% for ages 6-12, and 6.5% for ages ≥ 13. The estimated exploitation fraction of market-size females from Black Bay was 11.3% in 2009.

## Discussion

Exploitation fractions we calculated for female ciscoes harvested from Thunder and Black Bay were within or below the Lake Superior Technical Committee's recently recommended safe-harvest range of 10-15% annually (Stockwell et al. 2009). We previously reported two exploitation fractions for Black Bay based on mid-November 2008 sampling (Yule et al. 2009a). When only the abundance estimate of ciscoes present in zone 7 was used, annual exploitation from Black Bay was estimated at 29.5% (both sexes). When ciscoes sampled east of Black Bay proper (zone 9) were included in the at-large estimate, the exploitation fraction was estimated at 11.3% (Yule et al. 2009a). In the present study, we expanded our sampling effort to encompass a larger area outside of Black Bay that included sampling in both zone 6 (south and west of Black Bay, Figure 1) and zone 9 (east of Black Bay), and the resulting exploitation fraction of market-size female was estimated at 11.3%. Our present results also showed that the age distribution of ciscoes caught by MT outside of Black Bay was similar to the age distribution of ciscoes harvested from zones 6, 7 and 9 (Figure 14). Further the age structure of ciscoes caught by trawling from zones 6, 7 and 9 differed from ciscoes caught in zones 1-4, with Black Bay supporting a greater proportion of fish older than the 1992 year class (Figure 14) compared to Thunder Bay (Figure 12). These findings, coupled with previous findings that ciscoes move into Black Bay later then Thunder Bay (Yule et al. 2009a), suggest the two stocks are likely distinct. We recommend that additional tools be applied like fish morphometric analyses to explore if phenotypic differences exist, and that genetic analyses be conducted to provide further evidence that the two stocks are unique.

The presence of older ciscoes in Black Bay which had higher estimated exploitation fractions than Thunder Bay is a paradox. Our 2009 efforts to sample outside of Black Bay revealed the presence of spawning-size ciscoes at 20-40 water column depths, suggesting the fish were forming pre-spawning aggregations there. Yet, it is possible our sampling occurred too early in November and that more ciscoes arrived later. If true, then our Black Bay exploitation fractions may have been biased high. Because the exploitation fraction estimates have to be based on reliable estimates of spawner stock abundance in the area that is most intensely fished (southern Black Bay) more effort has to be devoted to (i) conducting fishery independent surveys in Black Bay proper in late November, or (ii) approximating the spawner abundance by broader spatial coverage by sampling adjacent zones in mid-November. We recommend that a combination of solution (i) and (ii) be applied during November 2010.

The density of spawning-size ciscoes returning to Thunder Bay has been tracking downwards (Figure 8). This trend is likely to continue given the absence of a strong year class after 2003. Further, the bulk of the 2009 Thunder Bay harvest was supported by only 2 year classes (Figure 12). If the current TAC of 180,502 kg is maintained and met in the future, it is likely that exploitation fractions will soon exceed the 15% safe-harvest limit.

Given the high likelihood gillnets will be used to ground truth acoustic data into the future, we collected samples to understand how using this sampling gear would affect survey results compared to MT gear. We found the multi-mesh gillnets fished at 10-11.8 m water column depth in Thunder Bay caught a lower proportion of females (39%) compared to MT samples (49%). The net effect of catching fewer females was abundance estimates of the two largest female age-classes were lower based on experimental gill net catches compared to MT catches (Figure 11). A lower female abundance estimate results in a higher female exploitation fraction. For example, when MT catches were used to calculate exploitation fractions of market-size females (≥ age 6) from Thunder Bay, the estimate equaled 7.1%. When gillnet samples were used, exploitation of females equaled 10.4%. Analysis of sex ratios measured by MT samples fished at varying depths showed that at depths ranging from ≈ 8-15 m that females represented roughly 40% of the catch, consistent with our experimental gillnet results. We conclude that our 2009 estimates of exploitation fractions based on MT samples were more robust because these samples likely provided more accurate estimate of sex ratios. We recommend that more experimental gillnets be fished at a wider range of depths during November 2010 and that results be compared to MT sampling results.

With some recent turnover in staff at the UGLMU, the decision was made to use the R/V *Kiyi* for sampling Thunder and Black bays in mid-November 2010. The plan will be to repeat the mid-November 2009 AC and MT effort in both bays (Figure 1), and to increase experimental gill net effort in Thunder Bay by fishing more nets at a wider range of depths. The UGLMU also plans to collect a couple of nights of AC data with their own vessel so results can be compared to data gathered with the R/V *Kiyi*. If weather allows, we will attempt to use this same OMNR vessel to repeat sampling in zones 6, 7 and 9 in late November to determine how spawner abundance and spatial distribution patterns change between these two time intervals. Work to train UGLMU staff on acoustic data collection and processing methods will continue into 2011. We anticipate that a document describing SOPs for measuring spawner abundance will be finalized before the November 2011 collections are conducted.

## Acknowledgements

This research was funded cooperatively from monies from the Canadian Ontario Agreement (COA) using OMNR funds and USGS-GLSC base funds. We would like to thank Captain Joe Walters, First Mate Keith Peterson, and Engineer Chuck Carrier of the GLSC R/V *Kiyi* for their hard work in the field. Special thanks to the many OMNR employees who participated in field collections, especially Karen Schmidt for processing catches and Marj Doggett for recording lab data. The quality of this report was improved by the comments received from Drs. Owen Gorman and Thomas Mehner. Special thanks to Laura Graf for helping format the document, Lori Evrard for producing GIS products, and Gary Cholwek for constructed the Appendices. Reference to trade names does not imply endorsement by the U.S. or Canada governments.

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## Tables

Table 1. Midwater trawl catches from Canada waters of Lake Superior, 8-14 November, 2009. The percentages (%) sum to 100% for each study site.

| Study site | | Thunder Bay | | Black Bay | |
|---|---|---|---|---|---|
| Management zones | | 1-4 | | 6,7, and 9 | |
| Midwater trawl samples | | 15 | | 8 | |
| Common name | Latin binomial | # caught | % | # caught | % |
| Rainbow smelt | *Osmerus mordax* | 1,075 | 48.36 | 2,709 | 94.23 |
| Ninespine stickleback | *Pungitius pungitius* | 2 | 0.09 | 3 | 0.10 |
| Cisco | *Coregonus artedi* | 1,017 | 45.75 | 145 | 5.04 |
| Lake whitefish | *Coregonus clupeaformis* | 2 | 0.09 | 0 | 0.00 |
| Bloater | *Coregonus hoyi* | 31 | 1.39 | 2 | 0.07 |
| Kiyi | *Coregonus kiyi* | 2 | 0.09 | 1 | 0.03 |
| Pygmy whitefish | *Prosopium coulterii* | 1 | 0.04 | 0 | 0.00 |
| Unidentified chubs[1] | *Coregonus spp.* | 88 | 3.96 | 10 | 0.35 |
| Siscowet | *Salvelinus namaycush siscowet* | 1 | 0.04 | 0 | 0.00 |
| Lake trout (wild) | *Salvelinus namaycush* | 3 | 0.13 | 0 | 0.00 |
| Deepwater sculpin | *Myoxocephalus thompsonii* | 1 | 0.04 | 5 | 0.17 |
| Totals | | 2,223 | 100.00 | 2,875 | 100.00 |

[1] = mostly age-0 fish

Table 2. Experimental gillnet catches from Canada waters of Lake Superior, 8-14 November, 2009. The percentages (%) sum to 100% for each study site.

| Study site | Thunder Bay | | Black Bay | |
|---|---|---|---|---|
| Management zones | 1-4 | | 6,7, and 9 | |
| Gillnet lifts | 4 | | 1 | |
| Species | # caught | % | # caught | % |
| Cisco | 302 | 99.67 | 10 | 90.91 |
| Lake whitefish | 1 | 0.33 | 0 | 0.00 |
| Rainbow trout[1] | 0 | 0.00 | 1 | 9.09 |
| Totals | 303 | 100.00 | 11 | 100.00 |

[1] = *Oncorhyncus mykiss*

Table 3. Density (number/ha) of small (≤ 249 mm total length) and large fish measured with acoustic and midwater trawl methods during November 2009 by study site. Other small fish included ninespine stickleback, pygmy whitefish, deepwater sculpin and siscowet; other large fish included lake trout (wild) and lake whitefish. Lower 95% and Upper 95% equals lower and upper 95% confidence intervals, respectively.

| Study site | Thunder Bay | | | Black Bay | | |
|---|---|---|---|---|---|---|
| Management zone(s) | 1-4 | | | 6,7 and 9 | | |
| Small fish (≤ 249 mm) | Lower 95% | Observed | Upper 95% | Lower 95% | Observed | Upper 95% |
| Age-0 cisco (≤ 150 mm) | 11.0 | 22.8 | 33.2 | 3.1 | 5.3 | 7.8 |
| Age-0 chubs (≤ 120 mm) | 42.6 | 55.4 | 65.9 | 11.3 | 16.9 | 23.3 |
| Cisco male (150-249 mm) | 6.1 | 11.6 | 18.0 | 0.0 | 0.0 | 0.0 |
| Cisco female (150-249 mm) | 1.9 | 4.7 | 8.3 | 0.0 | 0.0 | 0.0 |
| Bloater (120-249 mm) | 15.6 | 25.0 | 35.9 | 0.0 | 0.0 | 0.0 |
| Kiyi (120-249 mm) | 0.4 | 1.8 | 3.1 | 0.5 | 1.8 | 3.4 |
| Other (≤ 249 mm) | 1.1 | 2.7 | 4.2 | 4.0 | 8.3 | 12.6 |
| Rainbow smelt (≤ 249 mm) | 740.3 | 849.5 | 961.9 | 1002.7 | 1617.6 | 2264.1 |
| Large fish (≥ 250 mm) | Lower 95% | Observed | Upper 95% | Lower 95% | Observed | Upper 95% |
| Cisco male | 30.4 | 39.8 | 49.6 | 7.0 | 10.0 | 13.2 |
| Cisco females | 30.7 | 40.7 | 49.1 | 16.6 | 22.2 | 28.7 |
| Bloater | 0.9 | 1.8 | 3.3 | 0.1 | 0.2 | 0.6 |
| Kiyi | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Other | 0.8 | 2.3 | 4.0 | 0.0 | 0.0 | 0.0 |

Table 4. Biomass (kg/ha) of small (≤ 249 mm total length) and large fish measured with acoustic and midwater trawl methods during November 2009 by study site. Other small fish included ninespine stickleback, pygmy whitefish, deepwater sculpin and siscowet; other large fish included lake trout (wild) and lake whitefish. Lower 95% and Upper 95% equals lower and upper 95% confidence intervals, respectively.

| Study site | Thunder Bay | | | Black Bay | | |
|---|---|---|---|---|---|---|
| Management zone(s) | 1-4 | | | 6,7 and 9 | | |
| Small fish (≤ 249 mm) | Lower 95% | Observed | Upper 95% | Lower 95% | Observed | Upper 95% |
| Age-0 cisco (≤ 150 mm) | 0.08 | 0.15 | 0.22 | 0.01 | 0.04 | 0.04 |
| Age-0 chubs (≤ 120 mm) | 0.11 | 0.15 | 0.17 | 0.04 | 0.07 | 0.08 |
| Cisco male (150-249 mm) | 0.50 | 0.96 | 1.47 | 0.00 | 0.00 | 0.00 |
| Cisco female (150-249 mm) | 0.20 | 0.51 | 0.92 | 0.00 | 0.00 | 0.00 |
| Bloater (120-249 mm) | 1.35 | 2.19 | 3.14 | 0.00 | 0.00 | 0.00 |
| Kiyi (120-249 mm) | 0.02 | 0.09 | 0.17 | 0.02 | 0.08 | 0.14 |
| Other (≤ 249 mm) | 0.00 | 0.01 | 0.02 | 0.00 | 0.01 | 0.00 |
| Rainbow smelt (≤ 249 mm) | 6.43 | 7.57 | 8.69 | 5.02 | 7.42 | 10.23 |
| Large fish (≥ 250 mm) | Lower 95% | Observed | Upper 95% | Lower 95% | Observed | Upper 95% |
| Cisco male | 9.12 | 12.04 | 14.93 | 2.01 | 2.94 | 4.01 |
| Cisco females | 10.25 | 13.91 | 16.89 | 5.79 | 7.76 | 10.01 |
| Bloater | 0.10 | 0.22 | 0.40 | 0.00 | 0.03 | 0.06 |
| Kiyi | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Other | 0.59 | 2.25 | 3.99 | 0.00 | 0.00 | 0.00 |

Table 5. Abundance (millions) of small (≤ 249 mm total length) and large fish measured with acoustic and midwater trawl methods during November 2009 by study site. Other small fish included ninespine stickleback, pygmy whitefish, deepwater sculpin and siscowet; other large fish included lake trout (wild) and lake whitefish. Lower 95% and Upper 95% equals lower and upper 95% confidence intervals, respectively.

| Study site | Thunder Bay | | | Black Bay | | |
|---|---|---|---|---|---|---|
| Management zone(s) | 1-4 | | | 6,7 and 9 | | |
| Small fish (≤ 249 mm) | Lower 95% | Observed | Upper 95% | Lower 95% | Observed | Upper 95% |
| Age-0 cisco (≤ 150 mm) | 0.85 | 1.77 | 2.58 | 0.16 | 0.27 | 0.40 |
| Age-0 chubs (≤ 120 mm) | 3.31 | 4.31 | 5.13 | 0.57 | 0.86 | 1.18 |
| Cisco male (150-249 mm) | 0.47 | 0.90 | 1.40 | 0.00 | 0.00 | 0.00 |
| Cisco female (150-249 mm) | 0.14 | 0.37 | 0.65 | 0.00 | 0.00 | 0.00 |
| Bloater (120-249 mm) | 1.22 | 1.94 | 2.79 | 0.00 | 0.00 | 0.00 |
| Kiyi (120-249 mm) | 0.03 | 0.14 | 0.24 | 0.03 | 0.09 | 0.17 |
| Other (≤ 249 mm) | 0.08 | 0.21 | 0.32 | 0.20 | 0.42 | 0.64 |
| Rainbow smelt (≤ 249 mm) | 57.56 | 66.05 | 74.79 | 50.74 | 81.86 | 114.57 |
| Large fish (≥ 250 mm) | Lower 95% | Observed | Upper 95% | Lower 95% | Observed | Upper 95% |
| Cisco male | 2.36 | 3.09 | 3.85 | 0.35 | 0.51 | 0.67 |
| Cisco females | 2.39 | 3.16 | 3.82 | 0.84 | 1.12 | 1.45 |
| Bloater | 0.07 | 0.14 | 0.26 | 0.00 | 0.01 | 0.03 |
| Kiyi | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Other | 0.06 | 0.18 | 0.31 | 0.00 | 0.00 | 0.00 |

Table 6. Total biomass (metric tons) of small (≤ 249 mm total length) and large fish measured with acoustic and midwater trawl methods during November 2009 by study site. Other small fish included ninespine stickleback, pygmy whitefish, deepwater sculpin and siscowet; other large fish included lake trout (wild) and lake whitefish. Lower 95% and Upper 95% equals lower and upper 95% confidence intervals, respectively.

| Study site | Thunder Bay | | | Black Bay | | |
|---|---|---|---|---|---|---|
| Management zone(s) | 1-4 | | | 6,7 and 9 | | |
| Small fish (≤ 249 mm) | Lower 95% | Observed | Upper 95% | Lower 95% | Observed | Upper 95% |
| Age-0 cisco (≤ 150 mm) | 5.8 | 11.7 | 17.4 | 0.7 | 2.0 | 2.0 |
| Age-0 chubs (≤ 120 mm) | 8.5 | 11.7 | 13.4 | 1.9 | 3.5 | 4.1 |
| Cisco male (150-249 mm) | 38.7 | 74.6 | 114.6 | 0.0 | 0.0 | 0.0 |
| Cisco female (150-249 mm) | 15.8 | 39.7 | 71.2 | 0.0 | 0.0 | 0.0 |
| Bloater (120-249 mm) | 105.3 | 170.3 | 244.4 | 0.0 | 0.0 | 0.0 |
| Kiyi (120-249 mm) | 1.2 | 7.0 | 13.0 | 1.1 | 4.0 | 7.1 |
| Other (≤ 249 mm) | 0.2 | 0.8 | 1.9 | 0.1 | 0.5 | 0.9 |
| Rainbow smelt (≤ 249 mm) | 499.8 | 588.6 | 675.7 | 253.8 | 375.5 | 517.8 |
| Large fish (≥ 250 mm) | Lower 95% | Observed | Upper 95% | Lower 95% | Observed | Upper 95% |
| Cisco male | 708.8 | 936.1 | 1160.9 | 101.8 | 148.8 | 202.8 |
| Cisco females | 796.5 | 1081.5 | 1312.9 | 293.0 | 392.7 | 506.3 |
| Bloater | 8.0 | 17.1 | 30.9 | 0.2 | 1.5 | 3.0 |
| Kiyi | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Other | 45.8 | 174.9 | 309.8 | 0.0 | 0.0 | 0.0 |

Table 7. Total biomass harvested (kg), average mass of harvested males and females (g), and numbers of males and females harvested from Thunder Bay (Zones 1-3) and Black Bay (Zones 6, 7 and 9) during the roe fishery spanning November-December 2009.

| Management zone(s) | Biomass harvested (kg) | Average mass of harvested males (kg) | Average mass of harvested females (kg) | Number of males harvested | Number of females harvested |
|---|---|---|---|---|---|
| 1 | 83,670 | 0.378 | 0.406 | 80,015 | 131,790 |
| 2 | 71,924 | 0.402 | 0.423 | 55,279 | 117,469 |
| 3 | 4,000 | 0.383 | 0.395 | 4,445 | 5,812 |
| 1-3 | 159,594 | | | 139,740 | 255,071 |
| | | | | | |
| 6 | 16,297 | 0.603 | 0.603 | 9,547 | 17,481 |
| 7 | 40,975 | 0.494 | 0.521 | 28,999 | 51,159 |
| 9 | 42,870 | 0.423 | 0.443 | 28,324 | 69,721 |
| 6-9 | 100,142 | | | 66,870 | 138,361 |

A)

B)

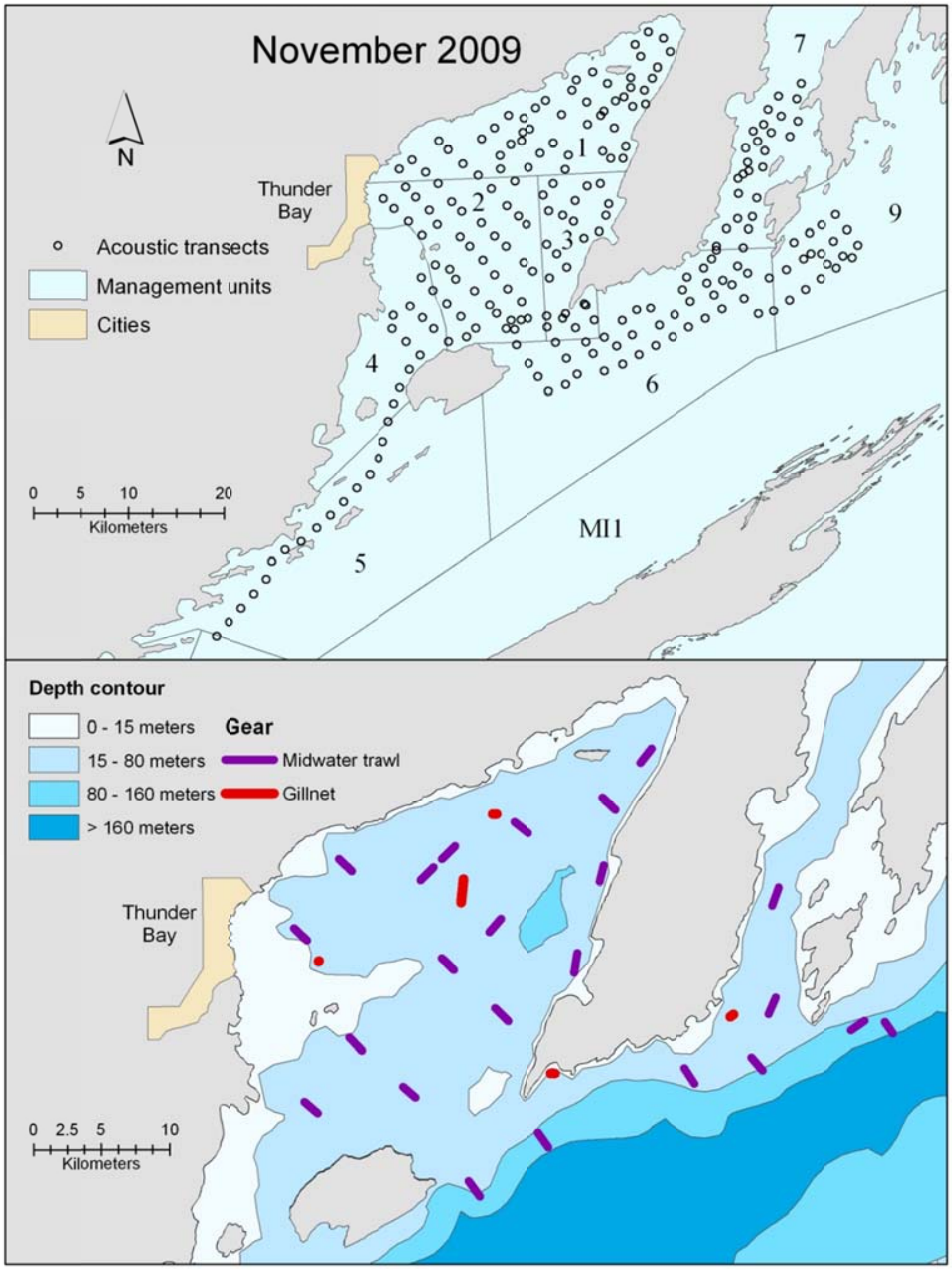


Figure 1. A) Map showing management unit boundaries and acoustic transects sampled 8-14 November 2009, and B) map showing bathymetry and midwater trawl and gillnet sites.

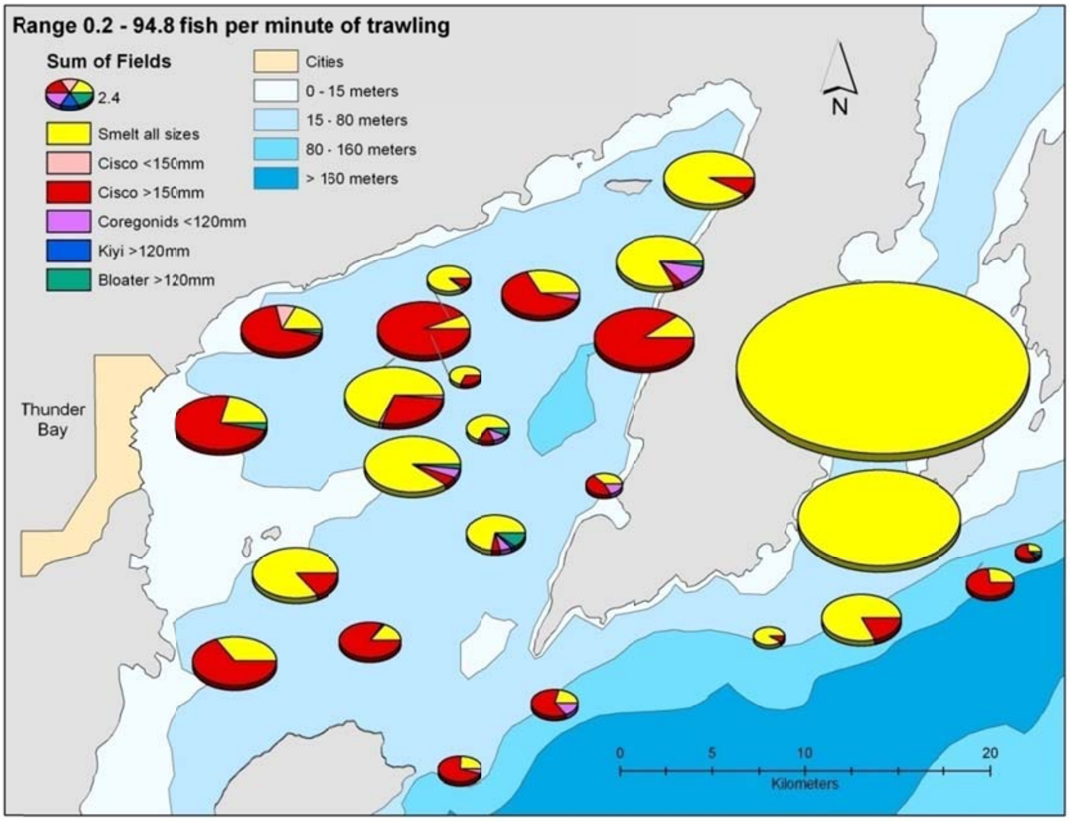


Figure 2. Map showing results of midwater trawl sampling. The size of the pie charts were graduated to the total number of fish caught per minute of trawling (range = 0.2 – 94.8/minute of trawling). Colors depict different species and size classes of fish. The pie chart size in the legend coincides with a catch of 2.4 fish/minute of trawling.

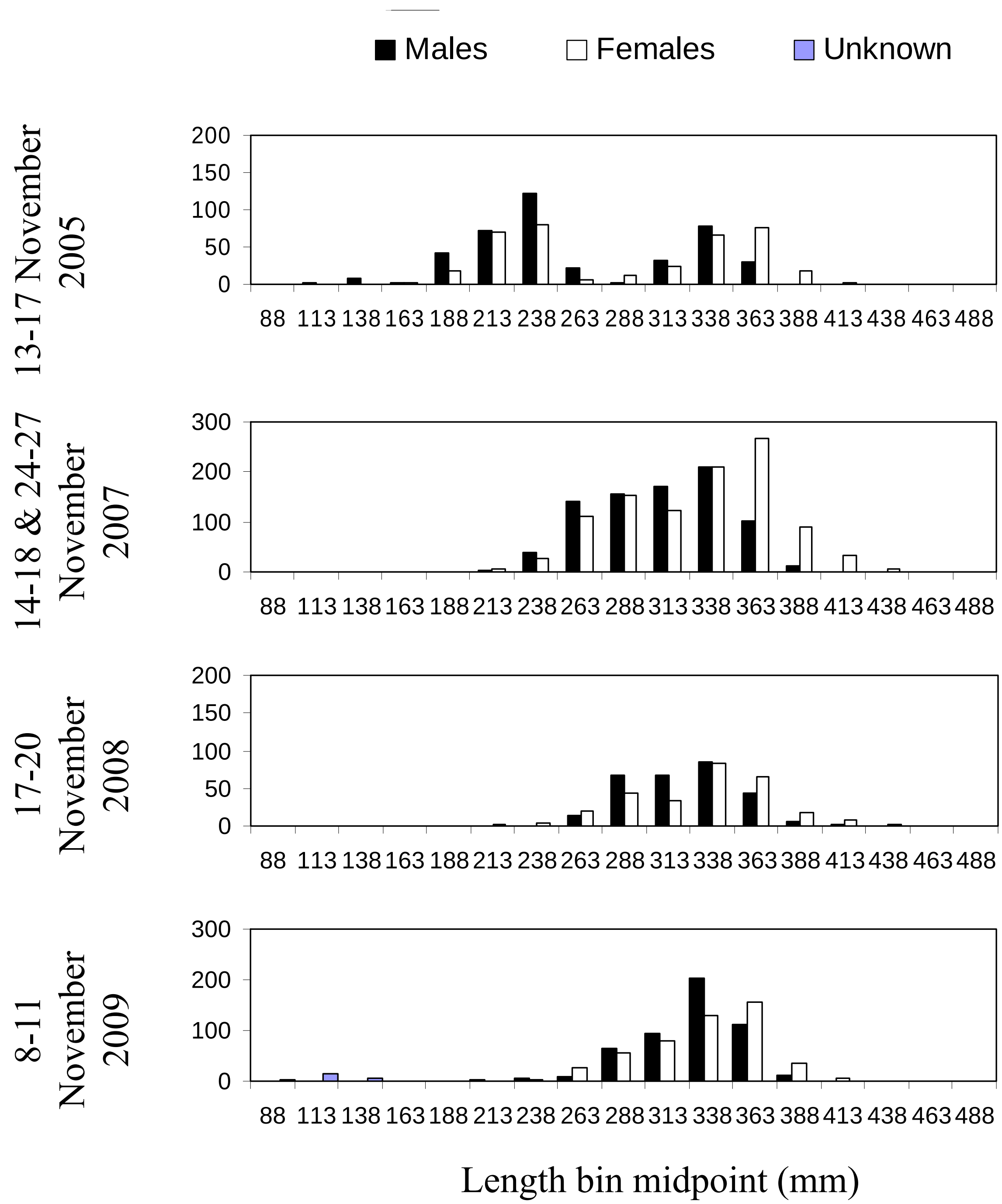


Figure 3. Length-frequency distributions of cisco captured from Thunder Bay in midwater trawl samples during Novembers 2005, 2007, 2008 and 2009. Two surveys were conducted during November 2007 so catches were pooled. Note the y-axis varies in the different panels. Age 0 ciscoes (< 150 mm) caught in 2009 could not be sexed.

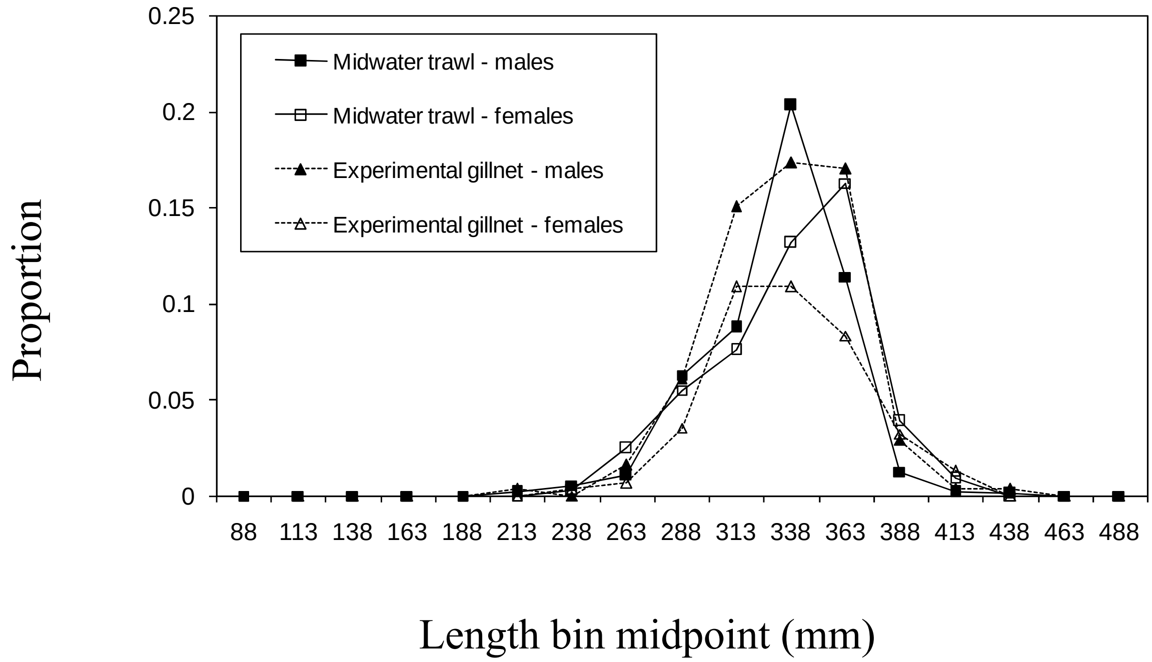


Figure 4. Length distributions of male and female cisco caught in all midwater trawl and all experimental gillnet samples, 8-14 November 2009. Proportions sum to 1 for each gear type. Of the ciscoes that could be sexed, a total of 566 males and 566 females were caught by midwater trawling; 190 males and 122 females were caught in experimental gillnets.

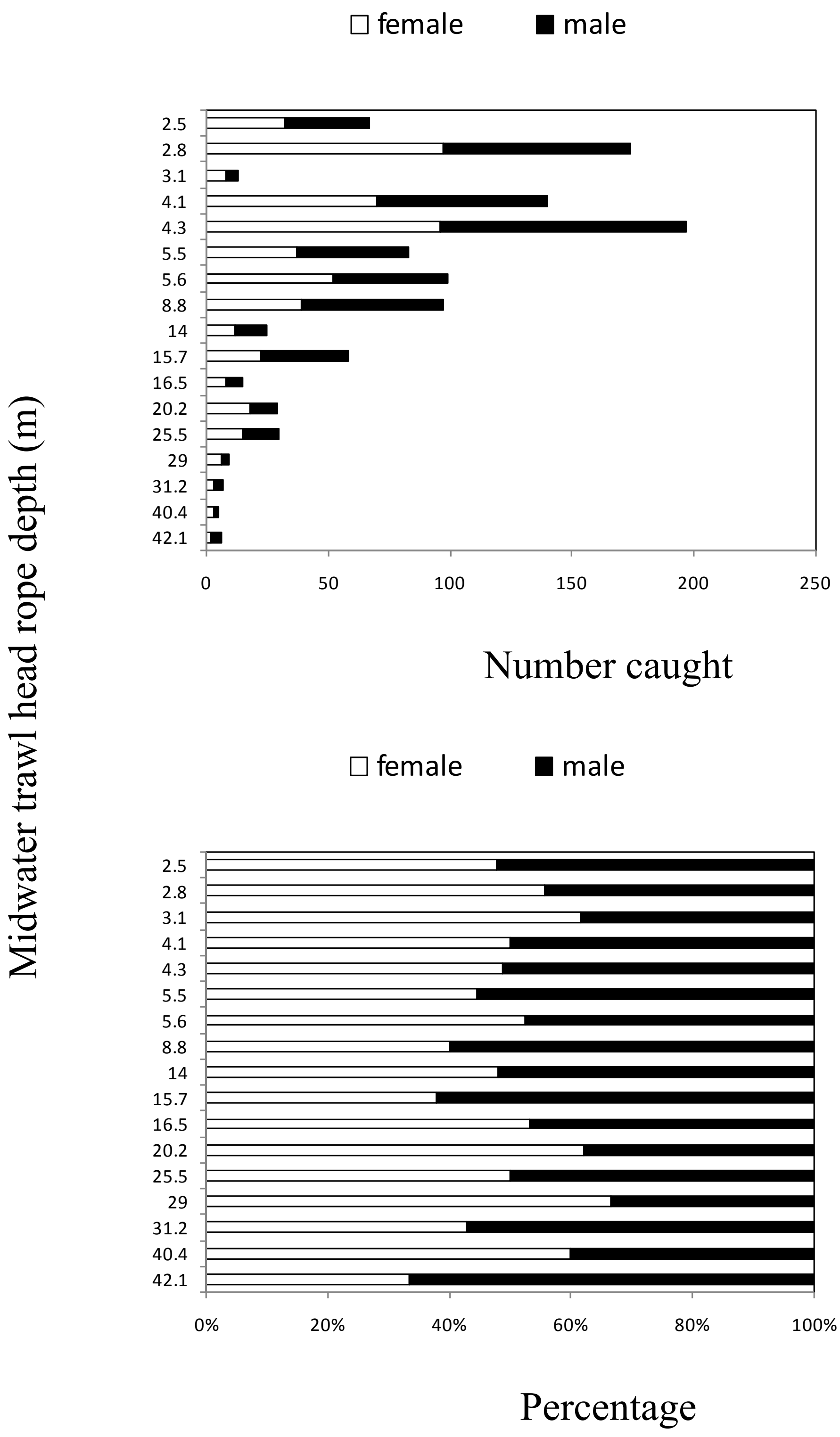


Figure 5. Catch of male and female ciscoes from Thunder Bay versus midwater trawl head rope depth.

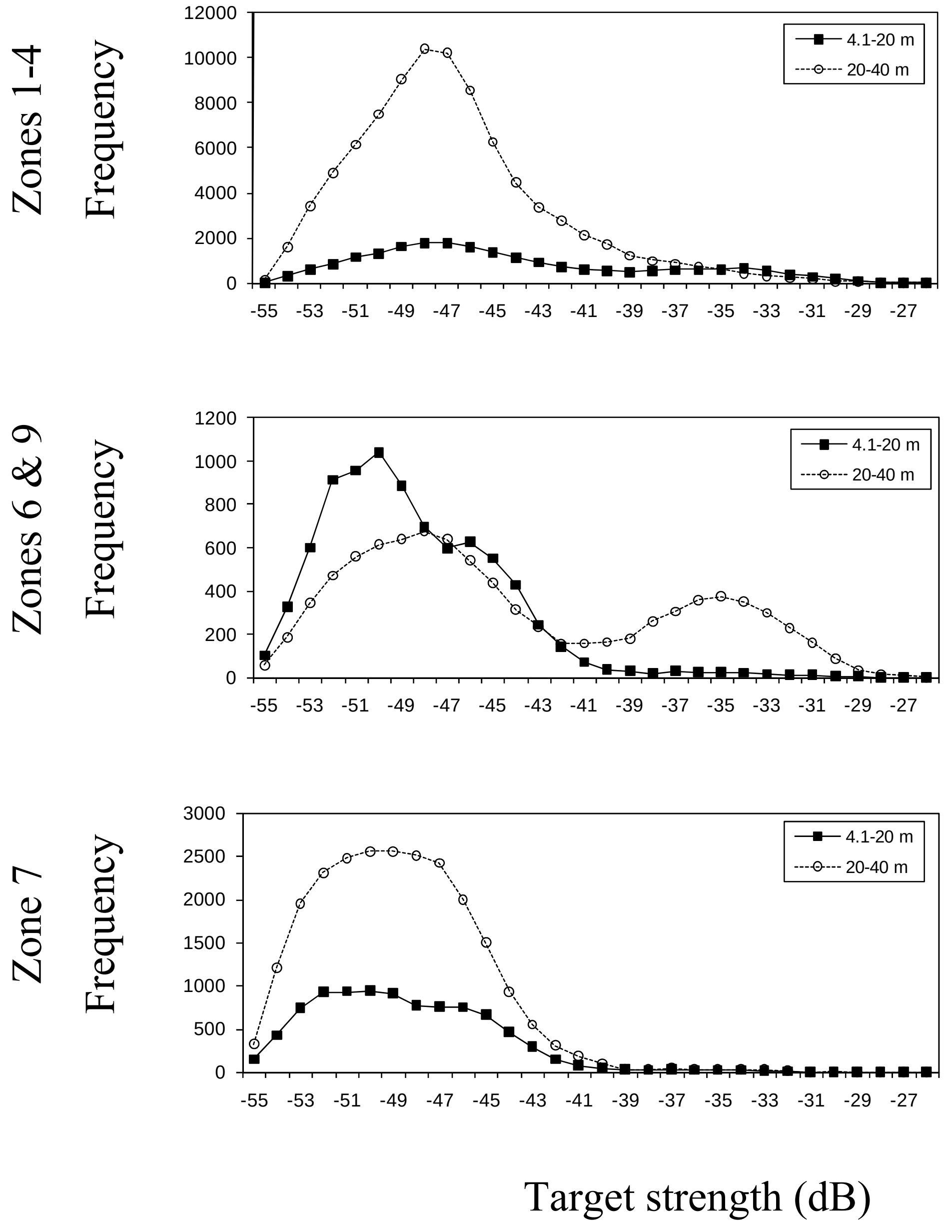


Figure 6. Acoustic target strength distributions from three regions of Canada sampled from 8-14, November 2009. Target strength in decibels (dB) is a measured with the acoustic gear, and represents an estimate of fish size obtained remotely. Distributions from two depth strata (targets between 4.1-20 m and 20-40 m water column depths) are presented for each region. Note the y-axis varies by panel.

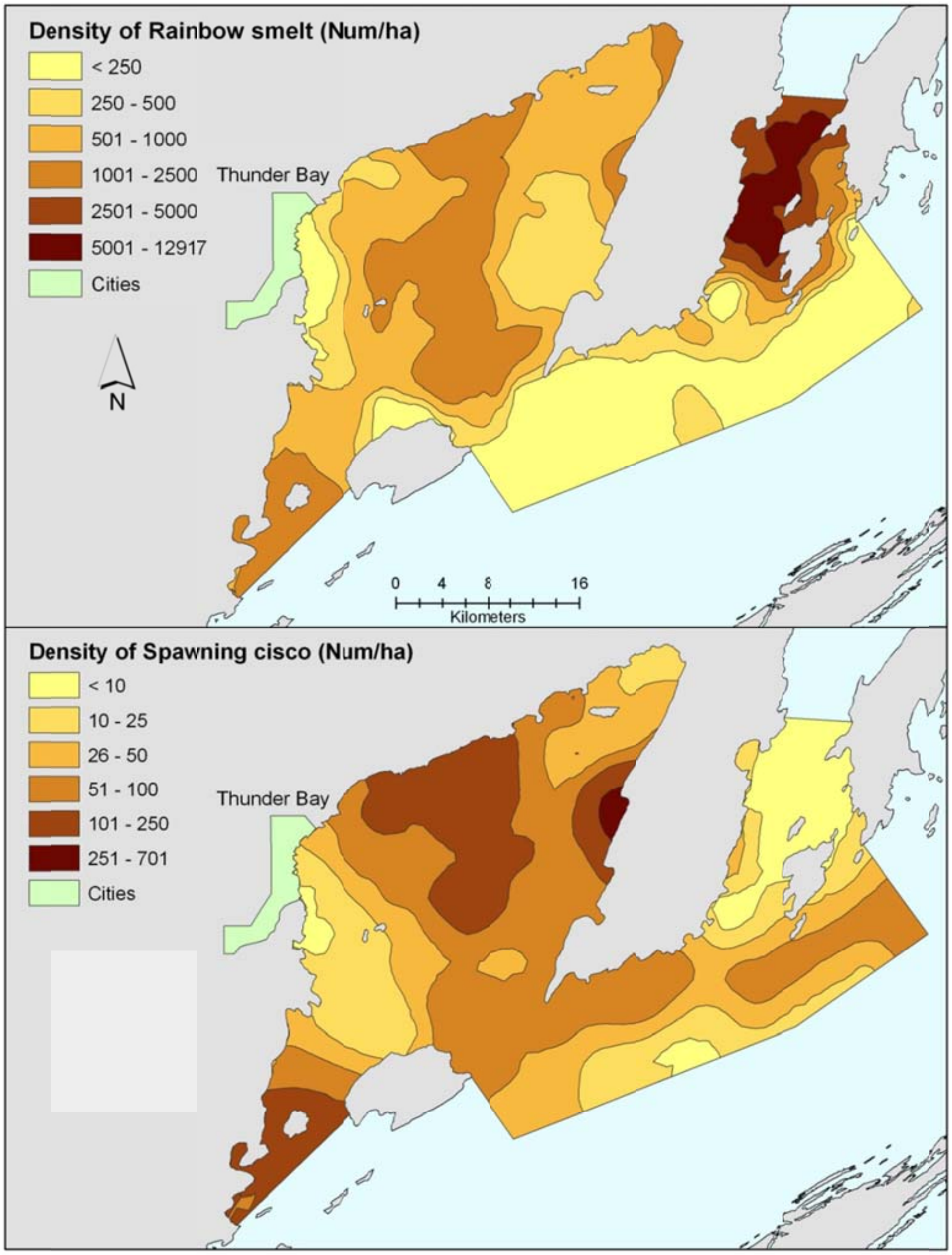


Figure 7. Maps showing densities of rainbow smelt (top panel) and spawning-size ciscoes (≥ 250 mm; both sexes; bottom panel) measured during an 8-14 November 2009 acoustic and midwater trawl survey. Surfaces were created using ordinary kriging (see Methods for details).

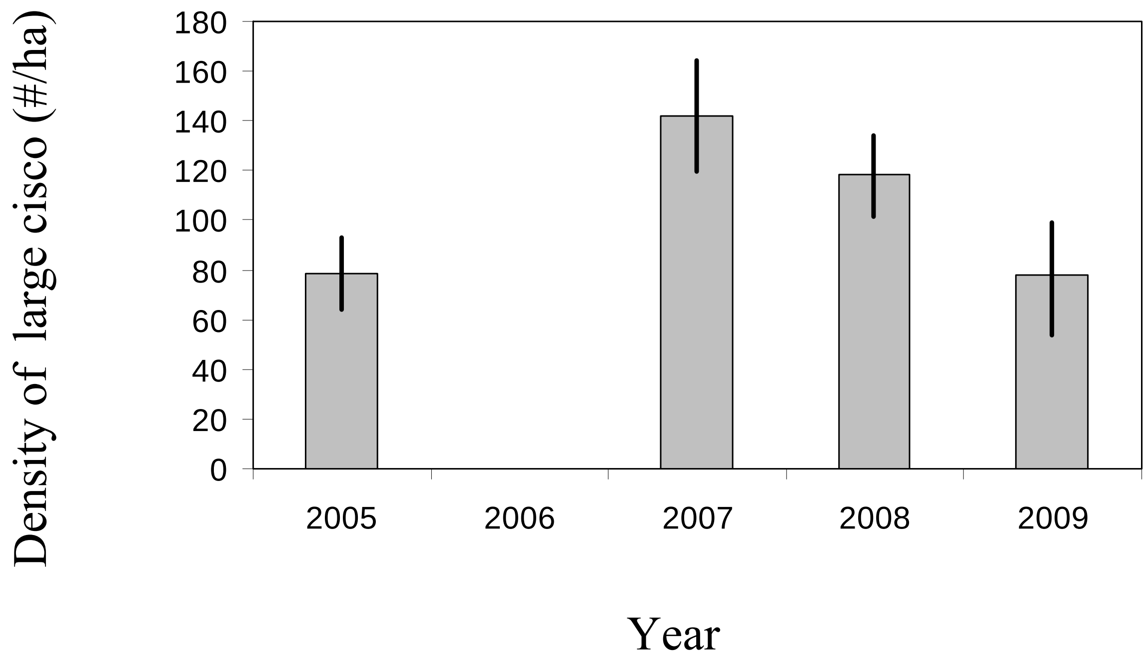


Figure 8. Average density of large (≥ 250 mm) ciscoes present in Thunder Bay during November 2005, 2007, 2008 and 2009. Error bars are 95% confidence intervals.

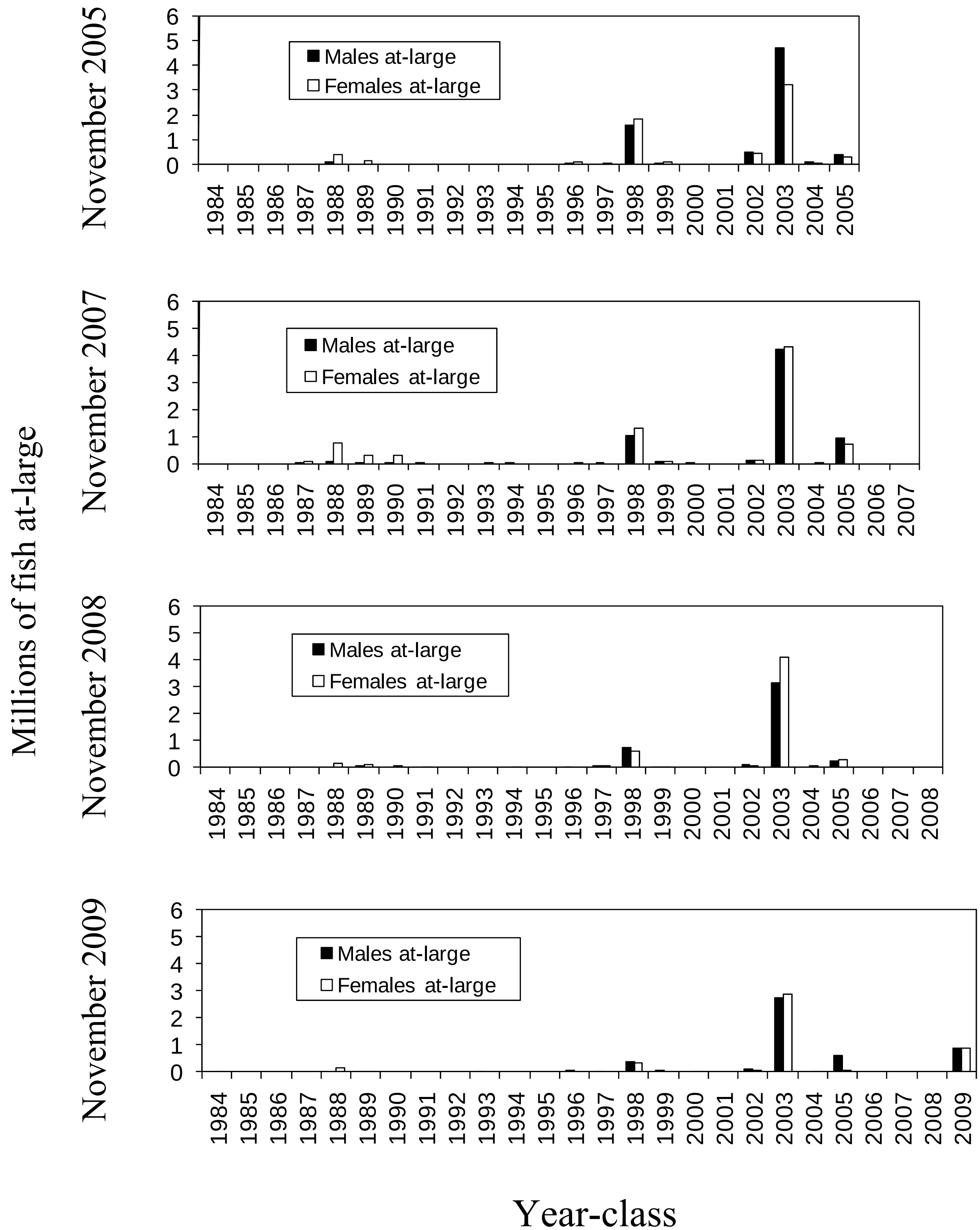


Figure 9. Estimated numbers (millions of fish) of ciscoes at-large in Thunder Bay belonging to different year classes during November 2005, 2007, 2008 and 2009.

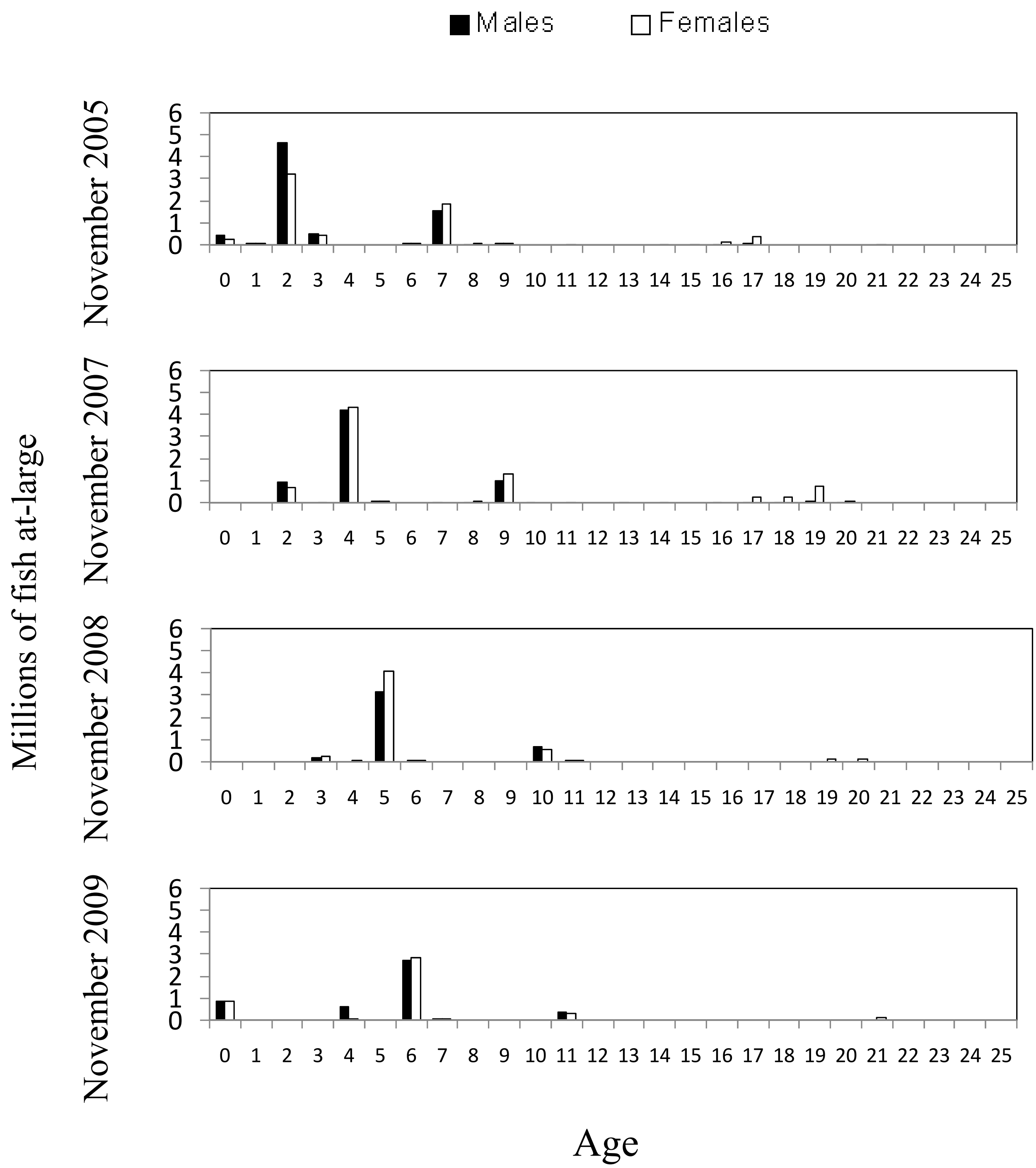


Figure 10. Estimated numbers (millions of fish) of ciscoes at-large in Thunder Bay belonging to different ages during November 2005, 2007, 2008 and 2009.

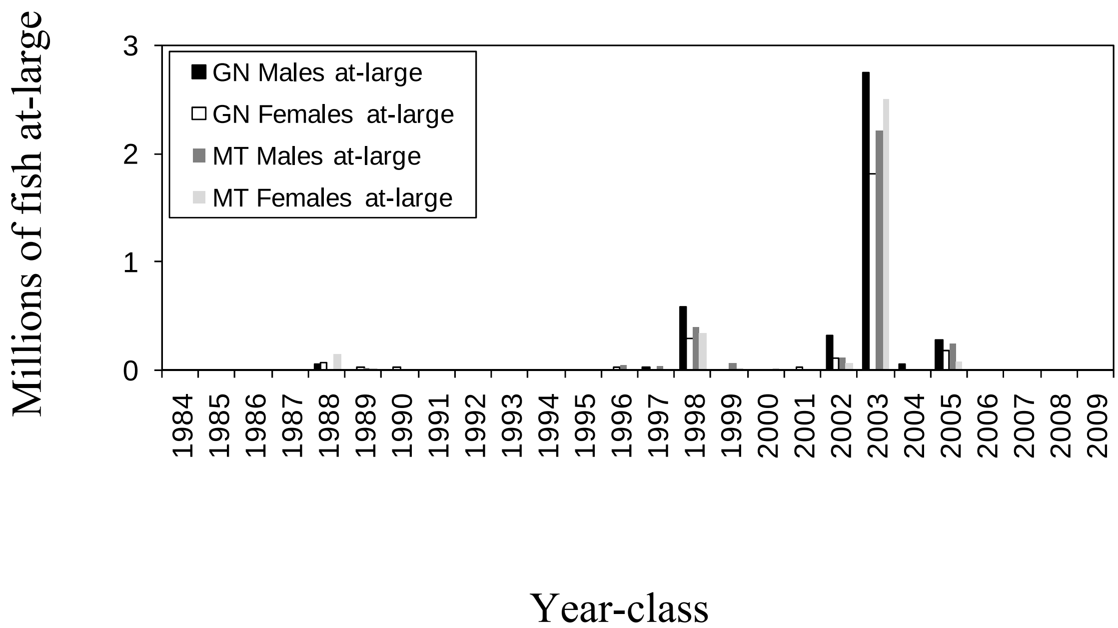


Figure 11. Estimated numbers of ciscoes of different year classes at-large in Thunder Bay during November 2009 based on age-length keys developed from ciscoes caught in experimental gill nets (GN) and midwater trawl (MT) samples.

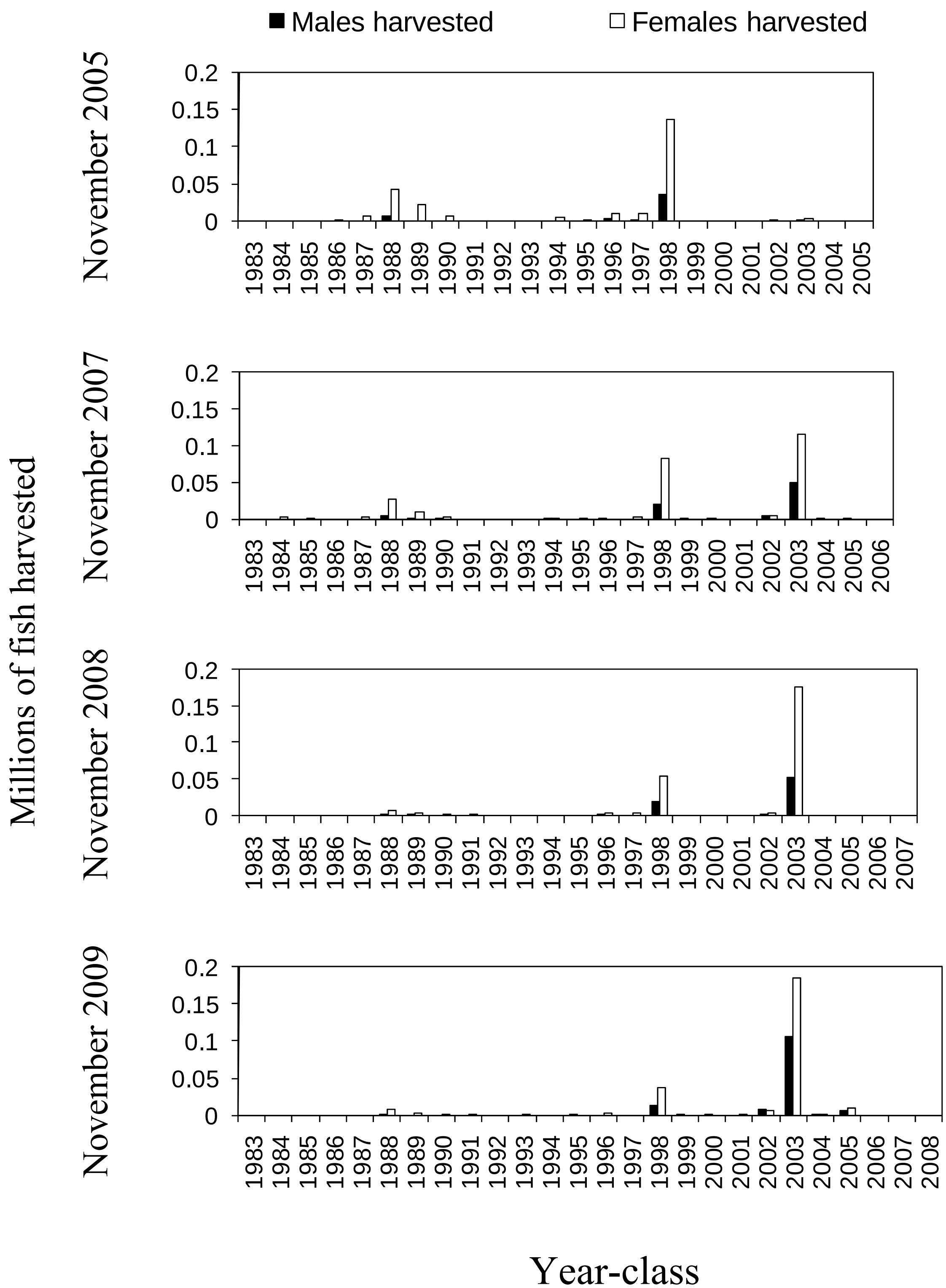


Figure 12. Estimated numbers (millions of fish) of male and female ciscoes of different year-classes harvested from Thunder Bay during November 2005, 2007, 2008 and 2009.

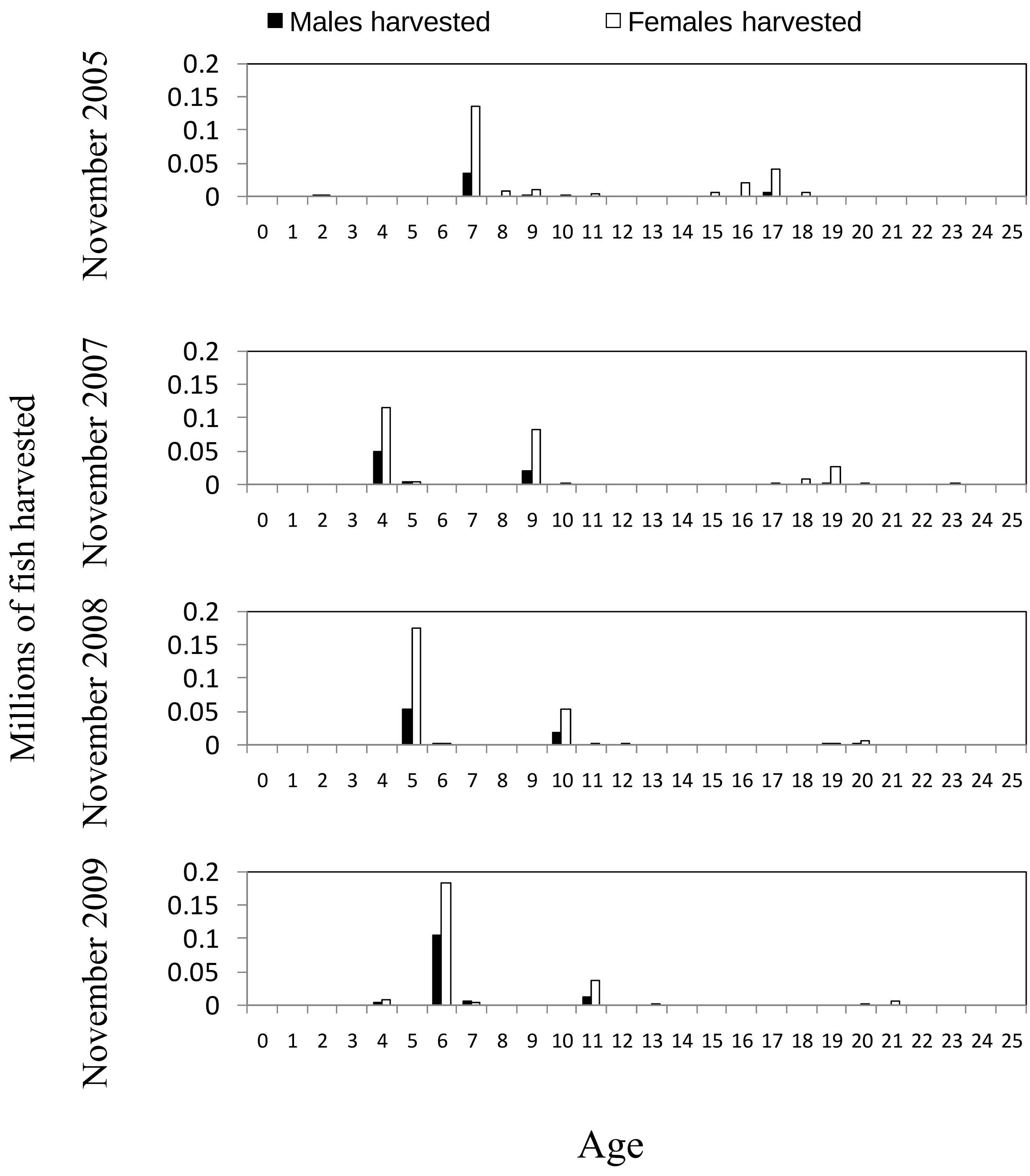


Figure 13. Estimated numbers (millions of fish) of male and female ciscoes of different ages harvested from Thunder Bay during November 2005, 2007, 2008 and 2009.

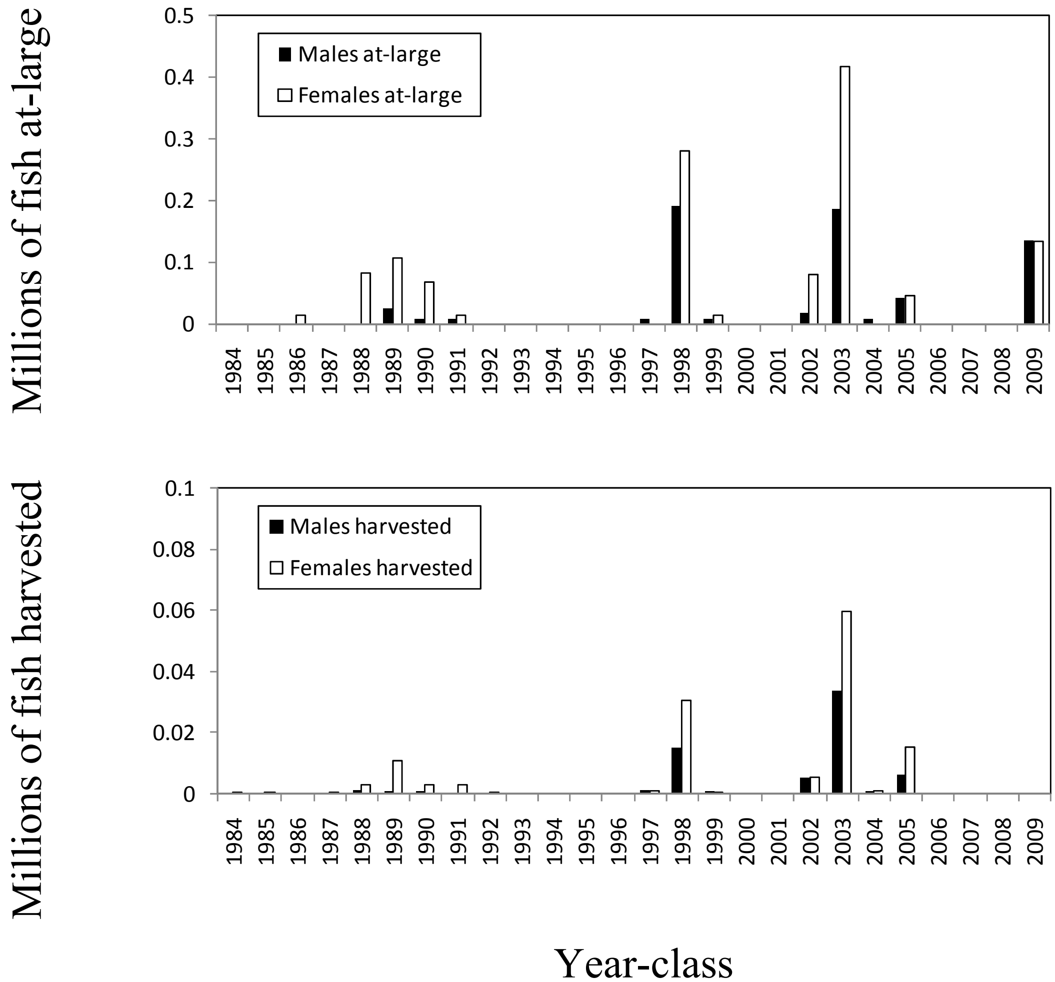


Figure 14. Estimated abundance at-large and numbers harvested of different year-classes in Black Bay, November 2009.

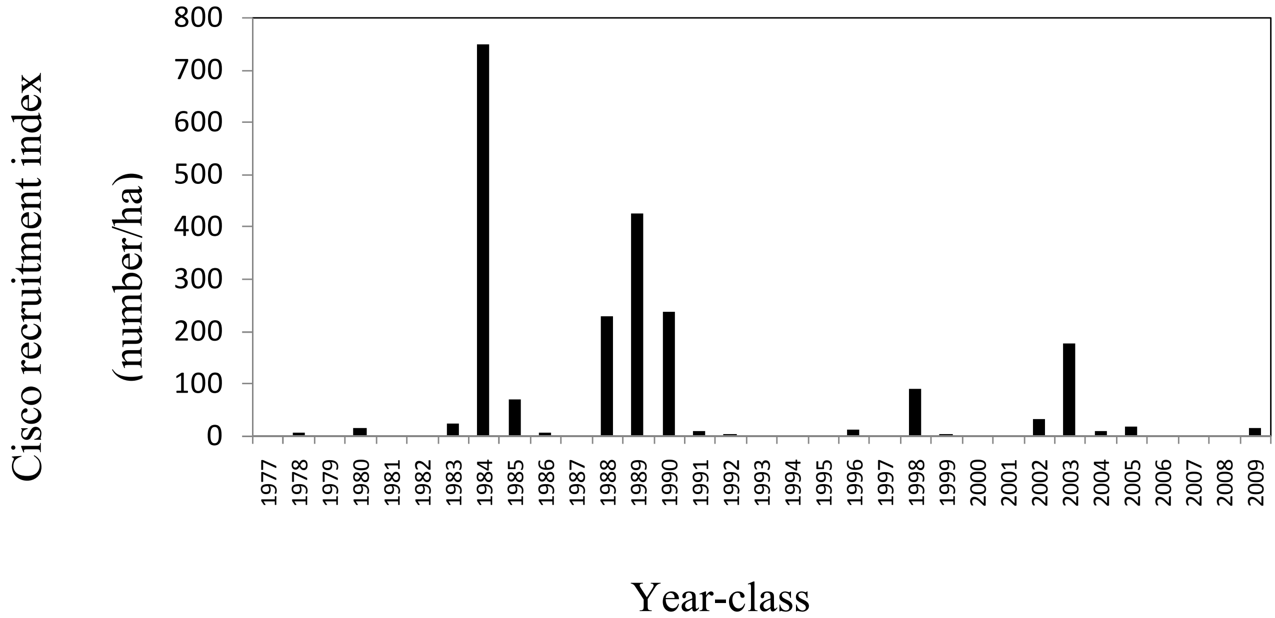


Figure 15. Year-class strength of cisco as indexed by the annual spring fish community survey of Lake Superior.

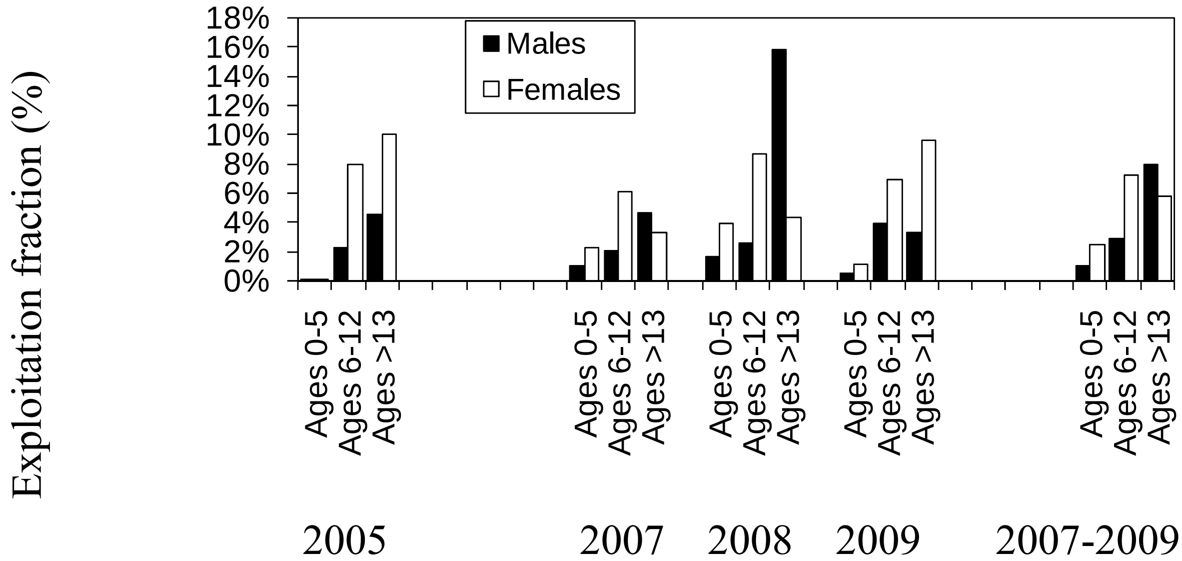


Figure 16. Estimated exploitation fractions (%) of three age-class groupings of ciscoes harvested from Thunder Bay during November 2005, 2007, 2008 and 2009 roe fisheries. The data to the far right (2007-2009) represents the averages calculated using the 2007-2009 data.

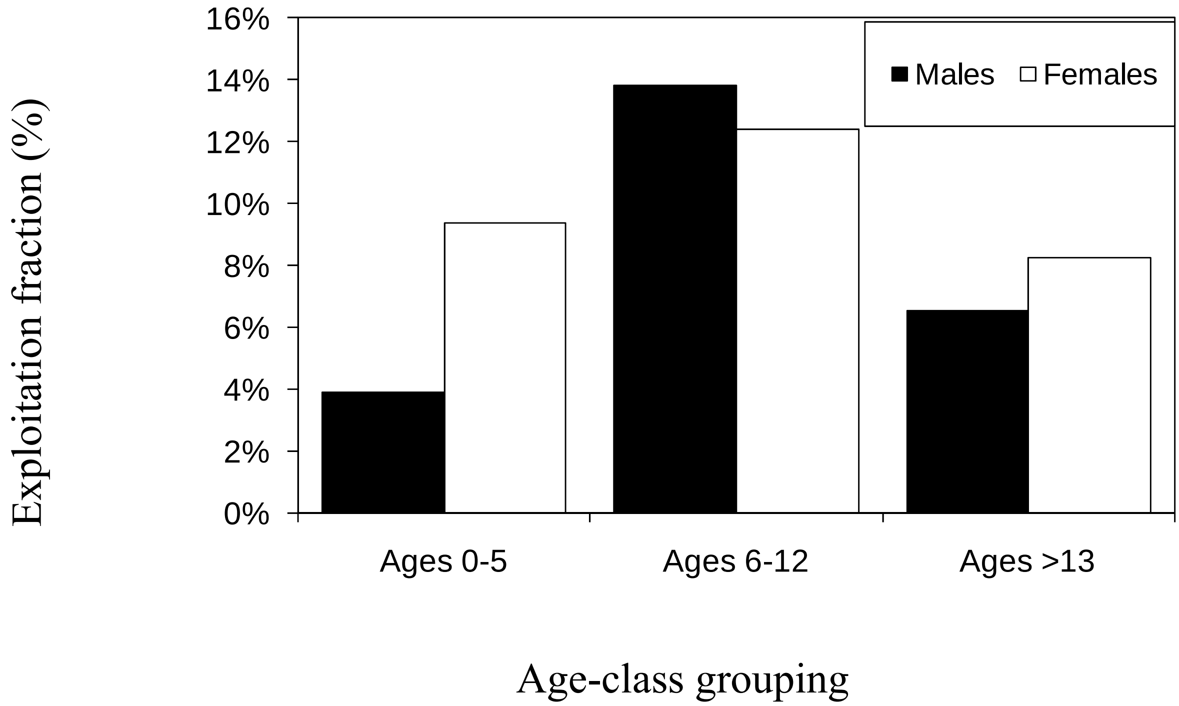


Figure 17. Estimated exploitation fractions (%) of different age-class groupings of ciscoes harvested from Black Bay during the November 2009 roe fishery.

Appendix A. Age-length distribution of male ciscoes caught by mid-water trawling in Thunder Bay (Management zones 1-4) during November 2009.

| **Year classes** | 2005 | 2003 | 2002 | 1999 | 1998 | 1997 | 1996 | 1993 | 1989 |
|---|---|---|---|---|---|---|---|---|---|
| **Length (mm) Age** | **4** | **6** | **7** | **10** | **11** | **12** | **13** | **16** | **20** |
| 140-149 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 200-209 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 220-229 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 230-239 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 240-249 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 250-259 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 260-269 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 270-279 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 280-289 | 3 | 10 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 290-299 | 10 | 27 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 300-309 | 10 | 32 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 310-319 | 12 | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 320-329 | 0 | 35 | 11 | 0 | 0 | 0 | 5 | 0 | 0 |
| 330-339 | 5 | 59 | 0 | 0 | 19 | 5 | 0 | 0 | 0 |
| 340-349 | 0 | 69 | 0 | 0 | 15 | 0 | 0 | 0 | 0 |
| 350-359 | 0 | 51 | 0 | 0 | 25 | 0 | 0 | 0 | 0 |
| 360-369 | 0 | 28 | 0 | 8 | 0 | 0 | 0 | 0 | 0 |
| 370-379 | 0 | 10 | 0 | 1 | 1 | 0 | 0 | 1 | 2 |
| 380-389 | 0 | 1 | 2 | 0 | 1 | 0 | 2 | 0 | 0 |
| 390-399 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 420-429 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| **Totals** | **44** | **366** | **19** | **9** | **62** | **5** | **7** | **1** | **2** |

Appendix B. Age-length distribution of female ciscoes caught by mid-water trawling in Thunder Bay (Management zones 1-4) during November 2009.

| Year Class | 2005 | 2004 | 2003 | 2002 | 2000 | 1999 | 1998 | 1989 | 1988 | 1984 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Length (mm)** **Age** | **4** | **5** | **6** | **7** | **9** | **10** | **11** | **20** | **21** | **25** |
| 240-249 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 250-259 | 2 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 260-269 | 1 | 0 | 10 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 270-279 | 0 | 0 | 11 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| 280-289 | 1 | 1 | 18 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 290-299 | 0 | 0 | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 300-309 | 0 | 0 | 23 | 0 | 0 | 0 | 4 | 0 | 0 | 0 |
| 310-319 | 4 | 0 | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 320-329 | 3 | 0 | 37 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 330-339 | 0 | 0 | 39 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 340-349 | 0 | 0 | 62 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 350-359 | 0 | 0 | 48 | 0 | 0 | 0 | 24 | 0 | 8 | 0 |
| 360-369 | 0 | 0 | 41 | 0 | 0 | 0 | 10 | 0 | 6 | 0 |
| 370-379 | 0 | 0 | 19 | 0 | 0 | 0 | 9 | 0 | 3 | 0 |
| 380-389 | 0 | 0 | 7 | 2 | 0 | 2 | 1 | 0 | 2 | 1 |
| 390-399 | 0 | 0 | 4 | 1 | 0 | 0 | 2 | 1 | 1 | 0 |
| 400-409 | 0 | 0 | 3 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| 410-419 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 420-429 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| **Totals** | **11** | **1** | **386** | **9** | **2** | **2** | **52** | **3** | **21** | **1** |

Appendix C. Age-length distribution of male ciscoes caught by midwater trawling from Management zones 6, 7 and 9 during November 2009.

| **Year classes** | 2005 | 2004 | 2003 | 2002 | 1999 | 1998 | 1997 | 1991 | 1990 | 1989 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Length (mm) Age** | **4** | **5** | **6** | **7** | **10** | **11** | **12** | **18** | **19** | **20** |
| 250-259 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 270-279 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 290-299 | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 300-309 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 310-319 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 320-329 | 0 | 1 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 330-339 | 2 | 0 | 3 | 0 | 0 | 5 | 0 | 0 | 1 | 0 |
| 340-349 | 0 | 0 | 4 | 0 | 0 | 6 | 0 | 1 | 0 | 1 |
| 350-359 | 1 | 0 | 4 | 0 | 1 | 8 | 1 | 0 | 0 | 0 |
| 360-369 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 370-379 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 1 |
| 380-389 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 390-399 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 410-419 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Totals** | **5** | **1** | **24** | **2** | **1** | **23** | **1** | **1** | **1** | **4** |

Appendix D. Age-length distribution of female ciscoes caught by midwater trawl from Management zones 6, 7, and 9 during November 2009.

| **Year classes** | 2005 | 2003 | 2002 | 1999 | 1998 | 1991 | 1990 | 1989 | 1988 | 1986 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Length (mm) Age** | **4** | **6** | **7** | **10** | **11** | **18** | **19** | **20** | **21** | **23** |
| 270-279 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 280-289 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 290-299 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 300-309 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 310-319 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 320-329 | 0 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 330-339 | 0 | 5 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 340-349 | 1 | 10 | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 0 |
| 350-359 | 0 | 3 | 1 | 1 | 6 | 0 | 1 | 4 | 2 | 0 |
| 360-369 | 0 | 0 | 0 | 0 | 5 | 1 | 1 | 1 | 0 | 0 |
| 370-379 | 0 | 0 | 2 | 0 | 3 | 0 | 0 | 2 | 1 | 0 |
| 380-389 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 1 | 1 |
| 390-399 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 400-409 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 410-419 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 420-429 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| **Totals** | **4** | **34** | **6** | **1** | **21** | **1** | **5** | **8** | **6** | **1** |

Appendix E. Age-length distribution of male ciscoes caught by experimental gillnet in Thunder Bay (Management zones 1-4) during November 2009.

| **Year classes** | 2005 | 2004 | 2003 | 2002 | 1998 | 1997 | 1988 |
|---|---|---|---|---|---|---|---|
| **Length (mm) Age** | **4** | **5** | **6** | **7** | **11** | **12** | **21** |
| 260-269 | 1 | 0 | 1 | 1 | 0 | 0 | 0 |
| 270-279 | 1 | 0 | 2 | 0 | 0 | 0 | 0 |
| 280-289 | 1 | 0 | 3 | 2 | 0 | 0 | 0 |
| 290-299 | 1 | 0 | 9 | 0 | 0 | 0 | 0 |
| 300-309 | 3 | 1 | 14 | 2 | 0 | 0 | 0 |
| 310-319 | 2 | 0 | 16 | 1 | 0 | 0 | 0 |
| 320-329 | 2 | 1 | 9 | 1 | 0 | 0 | 0 |
| 330-339 | 0 | 0 | 15 | 2 | 2 | 0 | 0 |
| 340-349 | 0 | 0 | 17 | 2 | 7 | 0 | 0 |
| 350-359 | 0 | 0 | 12 | 2 | 10 | 0 | 0 |
| 360-369 | 0 | 0 | 16 | 1 | 5 | 1 | 0 |
| 370-379 | 0 | 0 | 6 | 0 | 1 | 0 | 0 |
| 380-389 | 1 | 0 | 1 | 0 | 1 | 0 | 0 |
| 400-409 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 410-419 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 420-429 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| **Totals** | **12** | **2** | **122** | **14** | **26** | **1** | **2** |

Appendix F. Age-length distribution of female ciscoes caught by experimental gillnet in Thunder Bay (Management zones 1-4) during November 2009.

| Year Class | 2005 | 2003 | 2002 | 2001 | 1998 | 1996 | 1990 | 1989 | 1988 |
|---|---|---|---|---|---|---|---|---|---|
| **Length (mm) Age** | **4** | **6** | **7** | **8** | **11** | **13** | **19** | **20** | **21** |
| 260-269 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 270-279 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 280-289 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 290-299 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 300-309 | 0 | 10 | 2 | 0 | 1 | 0 | 0 | 0 | 0 |
| 310-319 | 2 | 9 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 320-329 | 1 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 330-339 | 2 | 10 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 340-349 | 0 | 10 | 1 | 0 | 2 | 0 | 0 | 0 | 0 |
| 350-359 | 0 | 7 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 360-369 | 0 | 7 | 0 | 0 | 5 | 0 | 0 | 0 | 0 |
| 370-379 | 1 | 4 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| 380-389 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 390-399 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 400-409 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 420-429 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| **Totals** | **8** | **81** | **5** | **1** | **13** | **1** | **1** | **1** | **3** |

Appendix G. Age-length distribution of male ciscoes caught by commercial gill nets in Thunder Bay (Management zones 1-4) during November 2009.

| **Year classes** | 2005 | 2004 | 2003 | 2002 | 2000 | 1999 | 1998 | 1995 | 1988 |
|---|---|---|---|---|---|---|---|---|---|
| **Length (mm) Age** | **4** | **5** | **6** | **7** | **9** | **10** | **11** | **14** | **21** |
| 310-319 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 320-329 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 330-339 | 0 | 0 | 9 | 1 | 0 | 0 | 1 | 0 | 0 |
| 340-349 | 0 | 0 | 20 | 1 | 0 | 0 | 3 | 0 | 0 |
| 350-359 | 1 | 1 | 26 | 1 | 0 | 0 | 4 | 0 | 0 |
| 360-369 | 4 | 0 | 38 | 3 | 0 | 1 | 7 | 1 | 0 |
| 370-379 | 0 | 1 | 23 | 0 | 1 | 0 | 1 | 0 | 1 |
| 380-389 | 1 | 0 | 19 | 2 | 0 | 0 | 1 | 0 | 1 |
| 390-399 | 2 | 0 | 8 | 2 | 0 | 1 | 0 | 0 | 0 |
| 400-409 | 1 | 0 | 6 | 1 | 0 | 0 | 0 | 0 | 0 |
| 410-419 | 0 | 0 | 4 | 1 | 0 | 0 | 2 | 0 | 0 |
| 420-429 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 430-439 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| **Totals** | **9** | **2** | **158** | **12** | **1** | **2** | **20** | **1** | **2** |

Appendix H. Age-length distribution of female ciscoes caught in commercial gill nets from Thunder Bay (Management zones 1-4) during November 2009.

| **Year classes** | 2005 | 2004 | 2003 | 2002 | 2001 | 1998 | 1996 | 1993 | 1991 | 1990 | 1989 | 1988 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Length (mm) Age** | **4** | **5** | **6** | **7** | **8** | **11** | **13** | **16** | **18** | **19** | **20** | **21** |
| 300-309 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 310-319 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 320-329 | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 330-339 | 1 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 340-349 | 0 | 0 | 28 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 350-359 | 4 | 0 | 53 | 1 | 0 | 5 | 0 | 0 | 1 | 0 | 0 | 0 |
| 360-369 | 3 | 2 | 66 | 1 | 1 | 15 | 0 | 1 | 0 | 1 | 0 | 3 |
| 370-379 | 0 | 1 | 47 | 3 | 0 | 12 | 0 | 0 | 0 | 1 | 0 | 3 |
| 380-389 | 1 | 0 | 56 | 3 | 0 | 9 | 2 | 0 | 0 | 1 | 1 | 2 |
| 390-399 | 1 | 0 | 23 | 0 | 0 | 5 | 2 | 0 | 0 | 0 | 1 | 1 |
| 400-409 | 4 | 0 | 9 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 2 | 2 |
| 410-419 | 0 | 0 | 10 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 2 |
| 420-429 | 0 | 0 | 3 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 430-439 | 0 | 0 | 2 | 0 | 0 | 3 | 0 | 1 | 0 | 0 | 0 | 0 |
| 440-449 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Totals** | **15** | **3** | **311** | **10** | **1** | **63** | **4** | **2** | **1** | **3** | **4** | **13** |

Appendix I.  Age-length distribution of male ciscoes caught by commercial gill nets from Management zones 6, 7 and 9 during November 2009.

| **Year classes** | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 | 1996 | 1990 | 1989 | 1988 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Length (mm)** **Age** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **19** | **20** | **21** |
| 280-289 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 290-299 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 300-309 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 320-329 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 330-339 | 2 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 340-349 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 1 |
| 350-359 | 5 | 0 | 20 | 4 | 0 | 0 | 1 | 9 | 1 | 0 | 1 | 0 | 0 |
| 360-369 | 8 | 0 | 27 | 6 | 0 | 0 | 0 | 10 | 1 | 0 | 0 | 0 | 0 |
| 370-379 | 2 | 3 | 19 | 4 | 1 | 1 | 0 | 13 | 1 | 0 | 0 | 0 | 0 |
| 380-389 | 4 | 1 | 21 | 2 | 0 | 0 | 0 | 10 | 1 | 0 | 0 | 1 | 1 |
| 390-399 | 3 | 0 | 15 | 0 | 0 | 0 | 1 | 7 | 0 | 0 | 0 | 1 | 1 |
| 400-409 | 2 | 0 | 11 | 1 | 0 | 0 | 0 | 6 | 1 | 0 | 1 | 0 | 1 |
| 410-419 | 0 | 0 | 14 | 1 | 0 | 1 | 0 | 4 | 0 | 1 | 0 | 1 | 0 |
| 420-429 | 0 | 0 | 4 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 430-439 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 440-449 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 450-459 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 470-479 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 500-509 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| **Totals** | **29** | **4** | **155** | **24** | **2** | **2** | **3** | **68** | **5** | **1** | **3** | **4** | **5** |

Appendix J. Length-age distribution of female ciscoes caught in commercial gill nets from Management zones 6, 7 and 9 during November 2009.

| Year Class | '06 | '05 | '04 | '03 | '02 | '01 | '99 | '98 | '97 | '94 | '93 | '92 | '91 | '90 | '89 | '88 | '87 | '86 | '85 | '84 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Length (mm) Age** | **3** | **4** | **5** | **6** | **7** | **8** | **10** | **11** | **12** | **15** | **16** | **17** | **18** | **19** | **20** | **21** | **22** | **23** | **24** | **25** |
| 270-279 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 280-289 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 290-299 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 310-319 | 1 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 320-329 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 330-339 | 0 | 5 | 0 | 8 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 340-349 | 0 | 13 | 1 | 17 | 2 | 0 | 0 | 5 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 350-359 | 0 | 14 | 2 | 42 | 3 | 0 | 1 | 12 | 1 | 0 | 0 | 0 | 0 | 0 | 4 | 2 | 0 | 0 | 0 | 0 |
| 360-369 | 0 | 14 | 0 | 49 | 5 | 0 | 2 | 31 | 0 | 0 | 0 | 0 | 3 | 3 | 6 | 2 | 0 | 0 | 1 | 0 |
| 370-379 | 0 | 5 | 0 | 47 | 5 | 0 | 0 | 20 | 0 | 0 | 0 | 1 | 3 | 2 | 7 | 2 | 1 | 0 | 0 | 1 |
| 380-389 | 0 | 5 | 1 | 28 | 2 | 0 | 0 | 14 | 0 | 0 | 0 | 0 | 1 | 2 | 7 | 3 | 1 | 0 | 0 | 0 |
| 390-399 | 0 | 2 | 0 | 22 | 1 | 1 | 0 | 16 | 0 | 0 | 1 | 0 | 0 | 1 | 6 | 1 | 0 | 0 | 1 | 2 |
| 400-409 | 0 | 1 | 0 | 6 | 1 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 3 | 1 | 4 | 0 | 0 | 1 | 0 | 0 |
| 410-419 | 0 | 1 | 0 | 9 | 1 | 0 | 0 | 7 | 1 | 0 | 0 | 0 | 2 | 1 | 3 | 1 | 0 | 0 | 0 | 0 |
| 420-429 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 6 | 0 | 1 | 0 | 0 | 0 | 1 | 3 | 1 | 0 | 0 | 0 | 0 |
| 430-439 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 4 | 0 | 0 | 0 | 0 | 0 |
| 440-449 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 490-499 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Totals*** | ***1*** | ***63*** | ***4*** | ***241*** | ***23*** | ***1*** | ***3*** | ***124*** | ***4*** | ***1*** | ***1*** | ***3*** | ***13*** | ***12*** | ***45*** | ***12*** | ***2*** | ***1*** | ***2*** | ***3*** |