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**ABUNDANCE AND STOCK CHARACTERISTICS  
OF THE ATLANTIC TOMCOD SPAWNING  
POPULATION IN THE HUDSON RIVER,  
WINTER 2003-2004**

**December 2006**

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WINTER 2003-2004**

*Prepared for*  
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**December 2006**

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**Abundance and Stock Characteristics of the Atlantic Tomcod  
Spawning Population in the Hudson River, Winter 2003-2004**

**EXECUTIVE SUMMARY**

- The population estimate of Atlantic tomcod spawning in the Hudson River during the winter of 2003-2004 was 1.7 million fish, with 95% confidence limits of 1.0 and 2.9 million fish. This Petersen estimate used Atlantic tomcod that were caught and marked between river miles 25 and 76 in box traps between 15 December 2003 and 1 February 2004 and recaptured by trawls in the Battery region during 5 January through 11 April 2004.
- The estimated 2003-2004 Atlantic tomcod spawning population in the Hudson River was the ninth lowest observed among 20 recent years of Petersen estimates. Previous estimates, in millions of fish, were 12.5 in 1982-1983, 6.7 in 1983-1984, 2.1 in 1985-1986, 3.5 in 1987-1988, 5.9 in 1988-1989, 6.8 in 1989-1990, 3.2 in 1990-1991, 0.4 in 1991-1992, 2.6 in 1992-1993, 0.7 in 1993-1994, 2.4 in 1994-1995, 0.09 in 1995-1996, 3.3 in 1996-1997, 1.3 in 1997-1998, 0.6 in 1998-1999, 0.2 in 1999-2000, 2.5 in 2000-2001, 0.04 in 2001-2002, and 0.1 in 2002-2003.
- Approximately 97% of the 2003-2004 Atlantic tomcod winter population were Age 1 fish. This was higher than in almost all of the previous 18 winter surveys, when Age 1 fish were 63-98% of the population.
- The sex composition, determined from Petersen estimates of the male and female population size, was approximately 28% males and 72% females. This was within the range observed in the 18 previous winter surveys, when males were 22-65% of the population.
- Fecundity of Age 1 and Age 2 females in 2003-2004 was higher than in most previous winter surveys. Above average fecundity was offset by a lower than average population, and total egg deposition for 2003-2004 was 28 billion eggs, which was about average compared with 1 billion eggs in 2002-2003, 1 billion eggs in 2001-2002, 28 billion eggs in 2000-2001, 3 billion eggs in 1999-2000, 10 billion eggs in 1998-1999, 23 billion eggs in 1997-1998, 47 billion eggs in 1996-1997, 2 billion eggs in 1995-96, 31 billion eggs in 1994-1995, 7 billion eggs in 1993-1994, 30 billion eggs in 1992-1993, 7 billion eggs in 1991-1992, 52 billion eggs in 1990-1991, 87 billion eggs in 1989-1990, 41 billion eggs in 1988-1989, 43 billion eggs in 1987-1988, 25 billion eggs in 1985-1986, and 75 billion eggs in 1983-1984.
- Atlantic tomcod peak spawning activity occurred during the peak catch per hour of females in box trap samples from the Tappan Zee, Cornwall, and West Point regions during the three-week period from 29 December 2003 through 18 January 2004.
- Trawl catch of Atlantic tomcod per ten-minute tow in the Battery region was highest from November through early December and late January through mid-February.
- Condition factors (weight at a given length) for both male and female Atlantic tomcod were generally comparable in 2003-2004 to condition factors observed in previous winter surveys.
- Nearly all Atlantic tomcod marked and released during this 2003-2004 survey were marked with visual implant tags. Finclips, which were the principal method of marking in 1997-1998 and the only method of marking for several years prior to that, were only used in one sample in 2003-2004.

### 1.0 INTRODUCTION

This report presents the findings of the 2003-2004 winter survey of the Atlantic tomcod (*Microgadus tomcod*) spawning population in the lower Hudson River. Data obtained by this survey were used to estimate (1) the size of the Atlantic tomcod spawning population in the Hudson River by the Petersen mark-recapture method (Ricker 1975), (2) population age and sex composition, (3) sexual maturity and the timing of peak spawning activity, (4) length, weight and condition of male and female fish, (5) individual, age-specific and population fecundity, (6) prespawning and postspawning population movements, (7) the validity of the population estimate, and (8) an annual index of Atlantic tomcod abundance based on trawl catch per unit of effort.

Surveys conducted during 1974-1975 through 1979-1980 (TI 1981) and during 1980-1981 and 1981-1982 (EA 1983) used Carlin tags or combinations of tags and finclips to mark Atlantic tomcod caught in box traps throughout the survey area. Box traps, impingement collections at Indian Point, Bowline, and Lovett generating stations, sport and commercial fishing returns, and incidental trawl catches provided recapture sampling efforts for these surveys (TI 1981). Examination of the movements of tagged fish (TI 1981) suggested that the Atlantic tomcod spawning population moved south into the lower Hudson and upper New York Harbor areas following peak spawning activity, which occurred during late December through early January in the West Point region. The present survey, as well as previous surveys, used this downriver population movement to provide random mixing of marked and unmarked fish for the Petersen mark-recapture statistic.

In 1982-1983 (NAI 1984a), the survey was modified to include (1) marking of Atlantic tomcod only in box traps set north of the Bear Mountain Bridge using finclip codes specific for one-week periods, and (2) trawl sampling, primarily south of the George Washington Bridge, to maximize the recapture of marked Atlantic tomcod in downriver regions. Marked fish were absent from the first peak of emigrating Atlantic tomcod caught in trawls south of the George Washington Bridge. The absence of marked fish implied that the first peak consisted largely of unmarked fish that had spawned south of the Bear Mountain Bridge. To evaluate this hypothesis, Atlantic tomcod were marked and released from box traps during the 1983-1984 survey both north and south of the Bear Mountain Bridge (NAI 1984b), extending the total marking area to Croton Point. Atlantic tomcod were finclipped using combinations of dorsal, anal and pelvic fins to designate four marking periods and four release zones. Recaptured fish were obtained from box traps, both north and south of the Bear Mountain Bridge, and from trawls sampling south of Croton Point.

Results from the 1983-1984 survey confirmed the hypothesis that Atlantic tomcod spawned south of the Bear Mountain Bridge. Atlantic tomcod marked and released between Croton Point and the Bear Mountain Bridge moved offshore and downriver where they were recaptured by trawling. Atlantic tomcod marked and released south of the Bear Mountain Bridge were generally recaptured before fish marked and released north of the bridge. Observations of the change in sex ratios across sampling weeks and recapture rates for marked fish among the release/recapture regions and time periods demonstrated that the best Petersen population estimate was obtained using all Atlantic tomcod marked in box traps north of Croton Point and recaptured by trawling south of the George Washington Bridge (NAI 1984b).

A spawning stock survey for Atlantic tomcod in the Hudson River was not conducted during the winter of 1984-1985. The survey was reinstated during the winter of 1985-1986 concurrent with a

## **2003-2004 Tomcod Report**

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winter-spring striped bass mark-recapture program (NAI 1986, 1987). The 1985-1986 Atlantic tomcod spawning stock survey was similar to the 1983-1984 survey and was expanded to provide two population estimates: (1) a prespawning population estimate based on fish marked in trawls south of the George Washington Bridge and recaptured in box traps north of Yonkers, and (2) a spawning population estimate based on fish marked in box traps at or north of Yonkers and recaptured in trawls south of the George Washington Bridge. Prespawning and spawning population estimates were not significantly different. The population estimate decreased from 12.5 million fish in 1982-1983 to 6.7 million fish in 1983-1984, and was lower still in 1985-1986 (2.1 million fish).

A mark-recapture survey for Atlantic tomcod was not conducted during the winter of 1986-1987. The Atlantic tomcod spawning stock mark-recapture survey was conducted concurrently with a striped bass hatchery evaluation program during the winter of 1987-1988 (NAI 1988). This Atlantic tomcod survey was similar to the 1985-1986 survey except weekly and biweekly marking periods were used instead of monthly periods to provide a more precise description of the temporal pattern of Atlantic tomcod movements during the spawning period. Prespawning and spawning population estimates were not significantly different. The spawning population estimate of 3.5 million fish represented an increase in abundance since 1985-1986. An Atlantic tomcod survey was conducted during the winters of 1988-1989 and 1989-1990 with no changes in methods. The resulting spawning population estimates were 5.9 million fish in 1988-1989 (NAI 1990) and 6.8 million fish in 1989-1990 (NAI 1991).

The 1990-1991, 1991-1992, 1992-1993, 1993-1994, 1994-1995, 1995-1996, 1996-1997, and 1997-1998 surveys (NAI 1992, 1994a, 1994b, 1995, 1998a; LMS 1999a, 1999b, 1999c) were identical in design to the 1987-1988 through 1989-1990 surveys with the exception that Atlantic tomcod were not finclipped in the trawl program. The trawl effort was used primarily to recover fish in the Battery and Upper Harbor regions that had been marked and released from box traps fished north of Yonkers. The spawning population estimate was 3.2 million fish in 1990-1991, 0.4 million fish in 1991-1992, 2.6 million fish in 1992-1993, 0.7 million fish in 1993-1994, 2.4 million fish in 1994-1995, 0.09 million fish in 1995-1996, 3.3 million fish in 1996-1997, and 1.3 million fish in 1997-1998.

A new aspect of the Atlantic tomcod program in 1997-1998 was visual implant (VI) tagging of approximately 24% of the fish that were caught in box traps and released with finclips. The purpose of these tags was to provide specific information on the distribution, movement rates, and growth of individual fish. Tag retention and legibility were 100% after 2.5 months for tags inserted under the skin of the right operculum, which was superior to the results of the other two tagging sites (below the right eye and on the right pectoral fin). Based on the success of the VI tags in 1997-1998, VI tags were used for all (or nearly all) marking of Atlantic tomcod beginning with the 1998-1999 program, replacing the fin clip method used in previous programs (with fin clips used only as a backup procedure). Individually numbered tags make it possible to determine the exact release date and station of each recaptured fish, compared to the previous fin clip method in which large batches of released fish were marked identically over a period of at least a week in one of two regions (north or south) each containing several stations. The spawning population estimate was 0.6 million fish in 1998-1999, 0.2 million fish in 1999-2000, 2.5 million fish in 2000-2001, 41,000 fish in 2001-2002, and 110,000 fish in 2002-2003.

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Similar to previous surveys, the 2003-2004 Atlantic tomcod spawning stock mark-recapture survey was conducted concurrently with a striped bass stock assessment. For the 2003-2004 program, VI tags were used for nearly all of the marking.

## **2.0 METHODS**

### **2.1 FIELD PROCEDURES**

Gear deployment and sample handling procedures are described in detail in a standard operating procedures manual (NAI 2003), and are summarized below.

#### **2.1.1 Box Trap Program**

From the week of 1 December 2003 through the week of 23 February 2004, box traps (Appendix Table A-1) were set in 1 to 12 m of water at 18 sites along the east and west banks of the Hudson River (Figure 2-1). The traps were lowered into the water by wire cable and firmly attached to a solid shore structure (e.g. dock, pier, bulkhead). The traps were generally checked and reset daily, Monday through Friday. Sites sampled in 2003-2004 included ones at or near all but four of the original 17 box trap sampling sites used consistently in all annual surveys from 1974-1975 through 1997-1998 (there were some minor shifts in position of a few of the sites). Two of the exceptions were sites with historically low catch rates at River Miles (RM) 18 and 19 in the Yonkers region that were discontinued after 1997-1998. Another exception was the Tarrytown trap site at RM 27 in the Tappan Zee region that was abandoned after 1999-2000. The fourth exception was the Milton trap site at RM 71 in the Poughkeepsie region that was abandoned after 2002-2003.

Extra traps have been used at various times since the 1997-1998 program to augment low catches, either at existing sampling sites or at new sites. In 1998-1999 an extra trap was added in RM 51 of the West Point region and an extra one in RM 56 of the Cornwall region. Four new trap sites were sampled in the West Point region during 1999-2000, one in RM 52 and the others in previously unsampled RM 54, 50, and 49. Traps in three locations were relocated slightly to a nearby site in the same RM. Two in RM 51 were relocated in December 1998 because access was denied by a new property owner and one in RM 41 where the site had become too shallow due to siltation was relocated in December 1999. In 2000-2001, additional changes were made to some of the trap locations. The extra trap in RM 51 and the recently established trap sites in RM 54, 50, and 49 were eliminated because they had been unproductive in 1999-2000. Extra traps were added in 2001-2002 at the Garrison site (RM 51, two more traps) and the Irvington site (RM 25, three more traps). Changes during the 2002-2003 program were the addition of an extra trap in RM 76 of the Poughkeepsie region, the elimination of two of the four traps in RM 51 at the Garrison site, and the elimination of two of the five traps in RM 25 at the Irvington site. Changes during this 2003-2004 program were the abandonment of the original Highland trap site in RM 76 of the Poughkeepsie region (retaining a newer site nearby in the same RM), the abandonment of the Milton site previously mentioned, and the addition of a second trap at the Marlboro site in RM 68 of the Poughkeepsie region.

The Hudson River from Tappan Zee north to Poughkeepsie was used as the box trap release/recapture zone in this survey. Atlantic tomcod caught in box traps in this zone were tagged with Northwest Marine Technology soft Vialpha fish tags. This tag is a small (1 mm x 3 mm), brightly-colored tag preprinted with a "tag number," a unique three-character identification code consisting of a letter followed by two digits or letters. The tag was inserted with a tag injector into the right cheek muscle of the fish. The length of each fish tagged was recorded before the fish was released. Fish recaptured with tags were released again as quickly as possible, approximately 25 to 50 meters away from the

capture site, after recording the length, condition of the tag insertion site (healed or infected), tag number, and condition of the fish (e.g., blind, fungus, finrot, stress). Recaptured fish with illegible tags, with tag wounds but no tags, or with other unusual features of the tag or tag wound were taken back to the laboratory for mark verification. Tags applied during this 2003-2004 survey were orange (with numbers between AAA and YZZ).

### **2.1.2 Trawl Program**

The Hudson River south of the George Washington Bridge and a portion of upper New York Harbor between Battery Park and Liberty Island were sampled by trawls (Figure 2-1). This region is collectively referred to as the Battery in this report.

A 9 m high-rise trawl (Appendix Table A-2) was deployed each weekday in the Battery from Monday, 3 November 2003, through Friday, 16 April 2004. The 9 m trawl was the same trawl used in all Atlantic tomcod surveys since 1982-1983. An average of 15 tows were scheduled to be made each day. Each tow was scheduled to last ten minutes, and the trawl was towed against the current at a boat speed (through water) of between 1.2 and 1.7 m per second. The towing wire was set with a length-to-depth ratio of between 2:1 and 4:1.

All Atlantic tomcod collected in trawls were examined for the presence of VI tags and for clipped fins, individually measured, and released. Suspected Atlantic tomcod recaptures from the current box trap program (Section 2.1.1 above) or from previous years were taken to the laboratory fresh or frozen for finclip or tag verification.

### **2.1.3 Biocharacteristics Samples**

Once a week between 9 December 2003 and 24 February 2004, an entire day's Atlantic tomcod catch from each of five standard box trap sites (Table 2-1) was taken in fresh condition to the laboratory and examined for biocharacteristics, which included enumeration of all Atlantic tomcod and determination of the age, length, weight, sex, and reproductive condition. These standard box trap sites were used in previous years' surveys and were selected to provide comparable biocharacteristics data for the Atlantic tomcod spawning stock. Additional samples from non-standard stations were used to supplement the biocharacteristics samples when catches at standard stations were low.

On one randomly assigned day during each week between 4 November 2003 and 15 April 2004, the entire catch from at least three 9-m trawl samples were taken in fresh condition to the laboratory for biocharacteristics analysis. Fish were taken to the laboratory from more than one day during weeks with low abundance of Atlantic tomcod in the trawl catch in an attempt to obtain a weekly sample of about 100 fish. The same data were recorded as for box trap biocharacteristics analysis.

### **2.1.4 Water Quality Measurements**

Conductivity and water temperature were measured *in situ*, with measurements corresponding to each box trap or trawl sample collection. Readings were made at the water surface and at sampling depth at box trap sites, and at the surface and sampling depth immediately after the completion of each 9 m trawl tow. Water quality data are summarized in Appendix Table B-1 for box trap samples and in Appendix Table B-2 for trawl samples. Bottom water salinity is summarized for box trap stations in Appendix Table B-3.

## **2.2 LABORATORY PROCEDURES**

The Atlantic tomcod in each biocharacteristics sample (box trap or trawl) were received in fresh condition in the laboratory. Date and place of recapture were recorded for any tagged or finclipped Atlantic tomcod included with the laboratory samples. Tag number or finclip type, age, length, and sex were also recorded for each verified recapture.

Total length (mm), weight (nearest 0.1 g), sex, reproductive condition, and age were recorded for all Atlantic tomcod in the weekly biocharacteristics samples. Atlantic tomcod were not subsampled by length group for biocharacteristics analysis. Reproductive condition categories included immature, developing, ripe, ripe and running, partially spent, spent, and resting (Table 2-2). Age was determined from one spawning season to the next. Atlantic tomcod over 150 mm were aged by counting the annuli of the otoliths (number of dark annual growth rings using reflected light), aided by a dissection microscope. Individuals 150 mm and under were considered to be Age 1 fish (TI 1980). Assignment to length group (Table 2-3) was done by computer based on the individual measurements.

Ovaries were collected from up to 15 Atlantic tomcod females per length group (Table 2-3) for fecundity analysis from box trap biocharacteristics samples. Ovaries were removed only from female Atlantic tomcod determined to be in or approaching ripe condition. Excised ovaries were preserved in 10% formalin. After at least one month of preservation, the egg mass was separated from the rest of the ovarian tissue, and weighed to the nearest hundredth of a gram. A randomly selected subsample of approximately 2 g was weighed (nearest 0.01 g) and the eggs in it were counted.

## **2.3 ANALYTICAL METHODS**

All box trap and trawl samples were assigned a Use Code (1, 2, or 5) that defined their use in analytical tasks. Use Code 1 samples were samples for which valid data were collected and no sampling problems were encountered. These data were used for all analytic tasks. Use Code 2 samples were samples in which Atlantic tomcod were captured, but sampling problems were encountered. Sampling problems were generally related to gear deployment that would affect computation of catch per unit of effort, such as noticing a tear in the net after a tow, or stopping a tow before the required 10-minute duration. Use Code 2 samples were included with Use Code 1 samples for mark-recapture or biocharacteristics analyses only. Use Code 5 samples were samples where sampling problems were encountered but no Atlantic tomcod were caught. Use Code 5 samples were excluded from all analyses. The number of samples assigned to each Use Code is presented for box traps and trawls in Appendix Table C-1.

Most data analyses were conducted using the Statistical Analysis System (SAS) software (SAS 1989). No rounding of data was done prior to the final step in each analysis. This prevented introduction of rounding error in the final result, and may present the appearance in a table that a column of data does not sum exactly to the total shown in the last row.

### **2.3.1 Estimates of Box Trap and Trawl Catch Per Unit of Effort (CPUE)**

All box trap catch statistics were expressed as catch per hour using the following formula:

$$CPUE_{\text{Trap}} = (C_i/D_i) \times 60$$

where

$C_i$  = number of Atlantic tomcod caught in box trap  $i$ , and  
 $D_i$  = duration in minutes over which trap  $i$  was fished.

Box trap sample durations approximated a 24-h period for the Tuesday through Friday samples (weekdays) and a 72-h period for the Monday samples (weekend), with occasional longer durations due to weather (ice) conditions.

All trawl catch statistics were expressed as catch per ten-minute tow using the following formula:

$$CPUE_{Trawl} = (C_i/D_i) \times 10$$

where

$C_i$  = number of Atlantic tomcod caught in trawl sample  $i$ , and  
 $D_i$  = duration of tow  $i$  in minutes. All Use Code 1 trawl tows were ten minutes in duration.

### 2.3.2 Age Distributions and Sex Ratios

Atlantic tomcod age distributions and sex ratios were obtained from laboratory biocharacteristics samples collected during each week of field sampling (Sections 2.1.3 and 2.2). The proportion of each age and sex was determined from the totals for all 2002-2003 biocharacteristics samples and extrapolated to the total 2002-2003 catch of Atlantic tomcod using the following equations:

$$P_{ij} = n_{ij}/n$$

$$N_{ij} = P_{ij}N$$

where  $P_{ij}$  = proportion of Atlantic tomcod in biocharacteristics samples that were age  $i$  and sex  $j$ ,  
 $n_{ij}$  = number of Atlantic tomcod in biocharacteristics samples that were age  $i$  and sex  $j$ ,  
 $n$  = total number of Atlantic tomcod of known age and sex in biocharacteristics samples,  
 $N_{ij}$  = estimated number of Atlantic tomcod in the total catch that were age  $i$  and sex  $j$ , and  
 $N$  = total number of Atlantic tomcod caught.

For calculation of sex ratios used in population estimates, the number and proportion of each sex for Atlantic tomcod was first determined within weekly intervals from the biocharacteristics data and then weighted by the weekly catch of Atlantic tomcod using the following equations:

$$Pm_j = m_j/n_j$$

$$Pf_j = f_j/n_j$$

$$M_j = Pm_j N_j$$

$$F_j = Pf_j N_j$$

where

$Pm_j$  or  $Pf_j$  = proportion of male or female Atlantic tomcod in week  $j$  in biocharacteristics samples,  
 $m_j$  or  $f_j$  = number of Atlantic tomcod males or females in week  $j$  in biocharacteristics samples,

- $n_j$  = number of Atlantic tomcod in week  $j$  in biocharacteristics samples,  
 $M_j$  or  $F_j$  = estimated total number of male or female Atlantic tomcod caught in week  $j$ , and  
 $N_j$  = total number of Atlantic tomcod caught in week  $j$ .

Weekly estimates of the number of each sex in the catch were then summed to provide an estimate for the entire sampling season.

### **2.3.3 Atlantic Tomcod Condition**

#### **2.3.3.1 Regression**

Regression analyses were used to characterize the relationship between fish length and weight for male and for female Atlantic tomcod, and between length and fecundity for ripe female Atlantic tomcod. All regression analyses were performed using the PROC GLM procedures of the Statistical Analysis System (SAS 1989). Logarithmic transformations (log to the base ten) were used to normalize length (total length in millimeters), weight (nearest 0.1 gram), and fecundity (number of eggs per female) variables. The following  $\log_{10}$ -linear regression models were calculated:

$$\text{Log}_{10} \text{ weight} = b_0 + b_1 (\text{Log}_{10} \text{ length})$$

$$\text{Log}_{10} \text{ fecundity} = b_0 + b_1 (\text{Log}_{10} \text{ length})$$

where

$b_1$  = regression slope coefficient, and

$b_0$  = y-axis intercept for the calculated regression line.

Confidence limits for values of weight or fecundity predicted for a given length from regression equations were calculated by the following equation (Neter and Wasserman 1974):

$$C_{95} = \hat{Y}_h \pm t_{(.05, n-2)} \sqrt{\text{MSE} \sqrt{1 + \frac{1}{n} + \frac{(X_h - \bar{X})^2}{\sum(X_i - \bar{X})^2}}}$$

where

$C_{95}$  = 95% confidence limits for  $\hat{Y}_h$ ,

$\hat{Y}_h$  = predicted value for dependent variable  $Y$  (e.g.  $\log_{10}$  weight or  $\log_{10}$  fecundity) corresponding to a  $\log_{10}$  length of  $X_h$ ,

$n$  = number of observations in the regression data set,

MSE = regression mean square error,

$\bar{X}$  = mean  $\log_{10}$  length within the regression data set, and

$\sum(X_i - \bar{X})^2$  = sum of squared deviations for the independent variable ( $\log_{10}$  length).

### **2.3.3.2 Pre- and Postspawning Condition**

The well-being or condition of Atlantic tomcod can be compared among groups of fish using condition factor indices or regression analysis and analysis of covariance (ANCOVA). Each approach has advantages and disadvantages that are best judged by the question being asked of the data. Condition factor indices represent a relative measure of “fatness” of fish at a given length (the greater the weight is at a given length, the higher the condition factor). Condition factors are particularly useful when tracking seasonal changes in subpopulations (Gabelhouse 1991) or comparing populations among regions (Gutreuter and Childress 1990, Springer et al. 1990). All condition factor indices require an assumption of isometric or allometric growth, and their formulation is dependent on the form of the age-length-weight relationship for individual fish (Ricker 1975, Anderson and Gutreuter 1983, Gutreuter 1987, Cone 1989). The assumption may be less critical if comparisons are made within the same age cohort and river system. If the form of the length-weight relationship is not known for the “standard” population, ANCOVA is recommended as a better approach than assuming a certain length-weight relationship (Ricker 1975, Anderson and Gutreuter 1983, Springer et al. 1990). The ANCOVA approach statistically compares regression lines for the length-weight relationships among several groups of fish, and tests for differences based on both the slope (form) and intercept coefficients. Regression lines can be significantly different due to differences in slope, intercept or both, while condition factor indices evaluate differences in slope and assume the intercepts are not significantly different. ANCOVA would be cumbersome, however, for tracking seasonal (weekly) trends or other contrasts with a large number of groups.

We used ANCOVA (SAS 1989) to compare differences in condition of prespawning and postspawning males and females. Weekly biocharacteristics data for Atlantic tomcod were subset based on reproductive condition (Table 2-2). Ripe fish were selected to represent the prespawning condition and spent fish were selected to represent the postspawning condition. Fish classified as immature, developing, or ripe and running were not used to characterize prespawning Atlantic tomcod because they are transitory stages and may have a wide range of gonadal weights that could increase the variability of the length-weight relationship. Similarly, fish classified as partially spent or resting were not used to describe the postspawning condition. The data were examined using scatter diagrams of  $\log_{10}$  weight vs.  $\log_{10}$  length to insure an adequate sample (10 or more fish) and a representative range of sizes (points not clustered). ANCOVA was then used to compare  $\log_{10}$  length vs.  $\log_{10}$  weight regressions of the pre- and postspawning male and female Atlantic tomcod from the trawl and box trap biocharacteristics samples. Predicted weight at a common length of 125 mm or 175 mm was back-transformed from the  $\log_{10}$  models and used to compare regression lines. The analysis was conducted within each of the past 16 surveys (1988-1989, 1989-1990, 1990-1991, 1991-1992, 1992-1993, 1993-1994, 1994-1995, 1995-1996, 1996-1997, 1997-1998, 1998-1999, 1999-2000, 2000-2001, 2001-2002, 2002-2003, and 2003-2004) to evaluate differences in Atlantic tomcod condition.

### **2.3.4 Petersen Estimate of Population Size**

An adjusted Petersen estimator (Ricker 1975) was the single census method used to calculate the size of the Atlantic tomcod spawning population in the Hudson River. For the Petersen estimates of the spawning population that have been calculated since 1982-1983, a known number of Atlantic tomcod were caught in box traps, marked, and released between Tappan Zee and Poughkeepsie during the spawning period. The fraction of Atlantic tomcod marked in box traps and recaptured by trawls in the Battery was used to estimate the spawning population size. The formula for the adjusted Petersen estimator (Ricker 1975) is

$$\hat{N} = [(M + 1)(C + 1)] / (R + 1)$$

where

$\hat{N}$  = estimated population size,

M = number of marked fish, adjusted for handling mortality,

C = number of fish examined for marks, and

R = number of marked fish recaptured.

Confidence intervals around the Petersen estimate were calculated by considering the number of recaptures as a Poisson variable (Ricker 1975):

$$\hat{N}_L = [(M + 1)(C + 1)] / (R_U + 1)$$

$$\hat{N}_U = [(M + 1)(C + 1)] / (R_L + 1)$$

where

$\hat{N}_U$  and  $\hat{N}_L$  = upper and lower limits for the estimated population size, and

$R_U$  and  $R_L$  = upper and lower 95% limits for a Poisson variable (R).

#### **2.3.4.1 Handling Mortality Adjustment**

The number of Atlantic tomcod marked and released (M) from box trap samples was adjusted for short-term handling mortality in two time periods using the following formula:

$$M = M_1 - [(M_1)(m_t)]$$

where

M = number of Atlantic tomcod marked, adjusted for handling mortality,

$M_1$  = number of marked fish released into the river, and

$m_t$  = short-term handling mortality for time interval t, expressed as a decimal percentage: 0.10 in December and 0.025 in January and February.

The values and time periods used for these short-term handling mortality adjustments for box traps were the same as used in previous surveys (TI 1981), in which finclipped (or Carlin tagged) and control fish were obtained weekly from box trap samples and held for 14 days in 190-liter aquaria supplied with spring-fed quarry water at the Verplank hatchery. Periods of time with similar handling mortality of finclipped Atlantic tomcod had been identified, and the actual percent mortality had been determined in each period.

#### **2.3.5 Distance and Rate of Movement for Tagged Atlantic Tomcod**

Visual implant tags used to mark nearly all of the Atlantic tomcod in 2003-2004 allowed more precise calculations of distance and rate of movement, compared to the finclipping method used in programs

prior to 1998-1999. Distance moved was represented by the linear distance traveled by VI-tagged Atlantic tomcod between the release and recapture river miles.

### 2.3.6 Fecundity

The number of eggs in the gonads of randomly selected ripe or ripe and running female Atlantic tomcod was estimated using a subsample-weight extrapolation. The following formula was used to estimate the number of eggs in the entire ovary of each fish:

$$\text{Fecundity} = \frac{\text{Number of eggs} \times \text{Gonad weight (g)}}{\text{Subsample weight (g)}}$$

### 2.3.7 Annual Trawl Index of Abundance

An annual trawl index of abundance was calculated as an additional measure of annual changes in Atlantic tomcod population size. Catch per unit of effort (CPUE) in the 9 m trawl was previously used to develop an index of Atlantic tomcod abundance for the 1982-1983 through 1998-1999 surveys (NAI 1995, NAI 2000). The 9 m trawl was selected because it was designed specifically to catch Atlantic tomcod, and has remained unchanged in mesh size and dimensions (Appendix Table A-2) since it was first used during the 1982-1983 survey. It has been fished with the same deployment procedures in the same region of the Hudson River across all sampling surveys. The CPUE index for the 9 m trawl in the Battery region was calculated for 2003-2004 using all river miles for the weeks of the Petersen estimate trawl recapture period, and was compared to the Atlantic tomcod population estimates derived from the Petersen estimator.

### 2.3.8 Salinity

Movement of the salt front in the Hudson River during the spawning period may influence Atlantic tomcod distribution, egg survival, and fertilization success, since Atlantic tomcod eggs resemble those of freshwater fishes in regard to salt tolerance and require salinities less than 15 ppt for successful fertilization (Peterson et al. 1980). Year to year differences in adult distribution and survival of eggs may be related to salt front intrusion in the lower Hudson River. Eggs spawned in the lower Hudson River, particularly between Yonkers and Indian Point, may be exposed to relatively high salinity water in some winters with low freshwater flows. Therefore, the movement of saline water during the winter spawning period may be an important covariate that helps explain annual variation in adult distribution and possibly the relationship between the Petersen population estimate and a trawl index of abundance. Weekly mean salinity levels in parts per thousand (ppt) were calculated from observed conductivity levels at the box trap sampling depth to determine the relationship between salt front position and annual variation in Atlantic tomcod distribution during the spawning period in the Tappan Zee, Croton-Haverstraw and Indian Point regions. Salinity was calculated following the method of TI (1976):

$$S = -100 \ln (1 - C_{25}/178,500)$$

where

$$S = \text{Salinity in ppt, and}$$

$$C_{25} = \text{Conductivity in } \mu\text{mho/cm at } 25^{\circ}\text{C.}$$

### **3.0 RESULTS AND DISCUSSION**

#### **3.1 SEASONAL ABUNDANCE PATTERNS**

Atlantic tomcod abundance in box trap samples from piers and bulkheads between Tappan Zee and Poughkeepsie increased to a peak in the week beginning 22 December 2003. The West Point and Tappan Zee regions contributed most to this peak (Figure 3-2), with C/H averages of 3.13 and 2.32 for that week. Seasonally, box trap C/H was highest during the five-week period from 22 December 2003 through the week of 19 January 2004 (0.34-1.85 fish per hour). The weekly C/H in the West Point region during the week of 22 December 2003 was the largest for a single region in any week (Figure 3-2).

Trawl catch of Atlantic tomcod per ten-minute tow (CPUE) in the Battery region was highest from November through early December and late January through mid-February (Figure 3-1; Appendix Table C-3). The highest CPUE during November-December was 13.1 fish per tow in the week beginning 17 November 2003. Catches declined during late December and were lowest in the two weeks beginning 29 December 2003 and 5 January 2004 (0.5-0.9 fish per tow). The CPUE then rose sharply over the next two weeks to the season's high of 14.8 fish per tow in the week of 19 January 2004. Trawling was not conducted the following week. When sampling was resumed, the trawl CPUE was in decline, finally stabilizing between 1.9 and 4.3 fish per tow during March through mid-April.

The timing of the peaks in CPUE in the box traps and the trawls during the winter of 2003-2004 (Figure 3-1) is consistent with the Atlantic tomcod spawning migration described in previous winter population studies (NAI 1984a, 1984b, 1987, 1988, 1990, 1991, 1992, 1994a, 1994b, 1995, 1998a, 2000, 2006a, 2006b, 2006c, 2006d; LMS 1999a, 1999b, 1999c). The November through early December trawl CPUE between 8 and 13 fish per tow probably corresponds with the movement of prespawning Atlantic tomcod into and through the Battery region of the lower Hudson River estuary. The box trap peak C/H in late December through early January during a period of low trawl CPUE represents movement of spawning Atlantic tomcod into and through nearshore areas farther upriver, especially in the Tappan Zee and West Point regions. The increase in trawl CPUE and decline in box trap C/H in early 2003 corresponds with movement of Atlantic tomcod back down river into the Battery region following spawning.

#### **3.2 STOCK CHARACTERISTICS**

##### **3.2.1 Age and Sex Composition**

The vast majority of the 2003-2004 winter spawning population of Atlantic tomcod were Age 1 fish, accounting for an estimated 97% of the fish collected in box traps and 98% of the fish captured in 9 m trawls (Table 3-1). Most, if not all, of the remaining fish were Age 2, as no fish observed in box trap and trawl samples were Age 3.

The weekly catch per unit of effort (CPUE) of male and female Atlantic tomcod in the 9 m trawl and box traps is a measure of the weekly sex ratio. In the 9 m trawl, the CPUE of female Atlantic tomcod was higher than the CPUE of males in most weeks (Figure 3-3). Conversely, male CPUE in box traps was usually higher than female CPUE.

The difference in sex ratios between box traps and trawls is clarified by comparison of weekly trends. Male CPUE in trawls began to decline after the end of November and was low from late December through mid- to late January. CPUE for males was higher during February then low again in March and April. The period of lowest CPUE for males in trawls corresponded to the period when catch rates for males in box traps was the highest (late December through mid- to late January). The pattern of weekly change in male CPUE in the 9 m trawls and box traps indicated a movement of males upriver throughout December. More than a month after their upriver migration, males had moved downriver, as evidenced by increased numbers in trawls in early February. CPUE for males in box traps decreased during January but significant numbers were still present in the week beginning 19 January, indicating that some males delayed their migration downriver until after that time. CPUE of female Atlantic tomcod in trawls declined later in the fall than it did for males. The declining CPUE of females in late December in trawls corresponded to increasing CPUE of females in box traps (Figure 3-3). Female Atlantic tomcod CPUE in box traps decreased after the week of 5 January 2004. These patterns of change in female CPUE in the 9 m trawl and box trap samples indicated a movement of females upriver in late December. After a brief period upriver, the females migrated downriver again. The high value of trawl CPUE in the week beginning 19 January (Figure 3-1) was composed primarily of females (Figure 3-3), indicating that female migration downriver occurred earlier than for males. Thus male and female Atlantic tomcod tended to be spatially segregated during prespawning and postspawning periods with males upriver and females downriver at these times.

The sex composition of the Atlantic tomcod spawning population can be estimated from the proportion of males and females derived from separate Petersen estimates of population size for males and females in the spawning population. This spawning estimate uses Atlantic tomcod caught, marked and released from box traps and recaptured by trawls. This procedure ensures that comparable numbers of both male and female fish are recaptured. Eight marked Atlantic tomcod males from the box traps were recaptured in the trawls, providing a Petersen spawning population estimate of 370,000 males with 95% confidence limits of 200,000 and 760,000. Five marked female Atlantic tomcod from the box traps were recaptured in the trawls, resulting in a Petersen estimate of 960,000 females with 95% confidence limits of 460,000 and 2,200,000. These estimates imply a proportion of males of 0.28, which was considerably lower than the proportion observed in the box traps during the late December to early January period of peak spawning (Appendix Table D-1), and more comparable to the proportion observed throughout most of the trawling program (Appendix Table D-1).

### **3.2.2 Maturity**

Ripe and running male Atlantic tomcod were first collected in box traps during the week of 22 December 2003 (Figure 3-4, Appendix Table D-2). By the week of 5 January 2004 most of the males appearing in box traps were partially spent and spent. During their period of peak abundance, ripe and running males were most abundant in box traps located in the West Point and Tappan Zee regions (Appendix Table D-3). Ripe females and ripe and running females were collected in box traps in greatest abundance during the three-week period from the week of 22 December 2003 through the week of 5 January 2004. Partially spent and spent female Atlantic tomcod were first collected in box traps during the week of 29 December 2003, and by the the week of 12 January 2004 about half of the females were in partially spent or spent condition. These data indicate that peak spawning occurred during the three-week period of 29 December 2003 through the week of 12 January 2004, when substantial numbers of both prespawning (ripe or ripe and running) and partially spent females were present (Figure 3-4).

Most of the fish captured in the Battery region by the trawl were in developing or ripe condition in November and early December and were spent or resting after the middle of January 2004 (Figure 3-5, Appendix Table D-4). These data collectively suggest an upriver prespawning migration with peak spawning beginning during the week of 29 December 2003 through the week of 12 January 2004, followed by a downriver postspawning migration.

### **3.2.3 Atlantic Tomcod Condition**

#### **3.2.3.1 Length-Weight Relationships**

Regression equations developed from biocharacteristics samples for the relationship between  $\log_{10}$  weight in grams and  $\log_{10}$  total length in millimeters for male Atlantic tomcod ( $n=987$ ; Appendix Figure D-1) and for females ( $n=1,837$ ; Appendix Figure D-2) were highly significant (Appendix Table D-5). Predicted weights for females tended to be heavier for a given length than for males (Table 3-2).

#### **3.2.3.2 Pre- and Postspawning Condition**

Male and female Atlantic tomcod captured by box traps and trawls were significantly heavier for a given length when in prespawning condition than when in postspawning condition in 2003-2004 (Table 3-3 and Appendix Table D-6). This was not surprising since total body weight included the weight of the gonad, which would be greatest when fish were in ripe condition and least when fish were in spent condition. Somatic weight was not used in this study because gonad weight was not determined for males, and gonads were only weighed for fecundity analysis from a small sample of females from the box traps.

Condition of Atlantic tomcod was compared not only between prespawning and postspawning fish, but also between fish caught upriver in box traps and fish caught downriver in trawls (Figure 3-6). Females captured in postspawning condition upriver in traps weighed approximately 30-40% less than when they were captured upriver in traps in prespawning condition one week earlier. Five weeks later when captured downriver in trawls, the females had regained about half of the lost weight. The postspawning increase in weight was faster for 125-mm females than for 175-mm females.

Male Atlantic tomcod captured downriver in trawls in prespawning condition were somewhat heavier for their length than males captured upriver in box traps four weeks later while still in prespawning condition. Males captured upriver in traps in postspawning condition weighed about 15% less than when they were captured upriver in box traps in prespawning condition about one week earlier. When males in postspawning condition were captured downriver in trawls six weeks later, they had regained a small amount of their lost weight (Figure 3-6).

In most previous surveys, males and females both exhibited weight loss during the upstream migration while in prespawning condition. This held true for males in 2003-2004, but females did not show any appreciable change in weight with only one week separating downriver trawl samples and upriver box trap samples. Females typically lose a higher proportion of their body weight while upstream during the peak spawning weeks, reflecting differences in weight of discharged gametes and this held true in 2003-2004. Females also regained a larger proportion of the weight lost during spawning by the time they were recaptured downriver several weeks after peak spawning. Differences between males and females in the timing of their downriver movement after spawning could affect the rates of regaining lost weight if food availability or feeding rates changed as the fish entered the warmer, higher salinity waters of the Battery region (Appendix Table B-3).

### 3.2.4 Fecundity

$\log_{10}$  fecundity was a linear function of  $\log_{10}$  length for female Atlantic tomcod (Appendix Figure D-3; Appendix Table D-5). The regression model accounted for 90% of the observed variation in fecundity ( $r^2 = 0.90$ ; Appendix Table D-5). Predicted fecundities for female Atlantic tomcod ranged from 4,800 to 32,400 eggs per fish for fish between 125 and 225 mm total length (Table 3-4).

Age-specific fecundity of Atlantic tomcod was estimated at approximately 21,200 eggs for Age 1 females and 69,000 eggs for Age 2 females during the 2003-2004 winter spawning survey (Table 3-5). Since fecundity is related to length, the greater mean fecundity for Age 2 fish was primarily due to their larger size compared to Age 1 fish. When the total 2002-2003 Atlantic tomcod population estimate (1.7 million spawning fish, Section 3.4) was multiplied by the percentage of females (72%, Section 3.2.1), the weighted mean fecundity (Table 3-5), and the percent composition of females in each age group (95.2% Age 1, 4.8% Age 2, Table 3-1), Age 1 females deposited an estimated 24 billion eggs and Age 2 females deposited approximately four billion eggs.

### 3.3 POPULATION DISTRIBUTION AND MOVEMENTS

Recapture of tagged Atlantic tomcod provided direct evidence of the duration, distance, and rate of movement of fish (Table 3-6, Appendix Tables E-2 through E-6). The 13 Atlantic tomcod marked and released in box traps set between Tappan Zee and Poughkeepsie were recaptured by trawls in the Battery region required 10 to 87 days to migrate downriver an average minimum distance of 31 river miles (79 km). Six of the fish were tagged and released in the North region and seven in the South region. Three males tagged and released in the North region migrated downriver an average of 49 miles in 26-43 days after they were released. Three females tagged and released in the North region migrated downriver an average of 44 miles in 32-87 days after they were released. Five males tagged and released in the South region migrated downriver an average of 18 miles in 24-57 days after they were released. Two females tagged and released in the South region migrated downriver an average of 20 miles in 10-37 days after they were released.

Most (193/222 or 87%) of the recaptured Atlantic tomcod were caught, marked, released, and recaptured in the same Hudson River region (Table 3-7). Movement within the North region accounted for 37% of the within-region movement of the recaptured Atlantic tomcod (82 of 222 fish), with 54 fish being released and recaptured within the South region and 71 being released and recaptured within the Battery region. The North region exhibited the highest recapture rate (R/M) and the Battery region exhibited the highest recapture proportion (R/C). Two fish marked and released in the North box trap region were recaptured in the South box trap region, but no fish marked and released in the South box trap region were recaptured in the North box trap region. Fourteen fish marked in the Battery region were recaptured upriver, nine of them in the North region and five in the South region.

There were 9,891 Atlantic tomcod tagged and released from the box traps between 1 December 2003 and 1 March 2004 and 3,479 Atlantic tomcod that were captured in the trawls and examined for tags between 1 December 2003 and 18 April 2004 (Table 3-8). All 13 tagged Atlantic tomcod that were recaptured in the trawls were tagged and released from the box traps in the three-week period 29 December 2003-18 January 2004, which was the three-week period of peak spawning. More than half (7 of 13) of the trawl recaptures were in the two week period of 2-15 February 2004. Those two weeks

had the highest recapture proportion (R/C row in Table 3-8) except for the week beginning 5 January, when one of only 13 fish caught by trawls was a recapture.

Peak Atlantic tomcod spawning occurred between 29 December 2003 and 18 January 2004 (Figure 3-4). The timing of this event is evident in the recapture patterns. One fish released from box traps in the South region was recaptured in the trawls in the week after the week it was released, but all 12 of the other trap-to-trawl recaptures were caught after the period of peak spawning, after being at large from four to twelve weeks. The 54 fish that were tagged in the South region and recaptured in box traps in the South region during 15 December 2003-22 February 2004 had been at large for an average of about one week (Appendix Table E-4). The 82 fish that were tagged in the North region and recaptured in box traps in the North region during 22 December 2003-25 January 2004 had been at large for an average of about one week (Appendix Table E-5). The two fish that were tagged in the North region and recaptured in box traps in the South region during 12 January-1 February 2004 had been at large for an average of about three weeks (Appendix Table E-6). One of those two fish was recaptured during the last of the three peak spawning weeks and the other was recaptured two weeks after that, suggesting that those two fish had begun their migration downriver. The relative timing of peaks in trawl CPUE and box trap C/H (Figure 3-1), the relative recapture locations (Table 3-7), and the dates and timing of the recapture of box-trap released Atlantic tomcod within and among Hudson River regions (Table 3-8, Appendix Tables E-2 through E-6) collectively support the assertion that the spawning population of Atlantic tomcod migrated from the Battery to shoal sites above Tappan Zee and then back to the Battery between December 2003 and April 2004.

### **3.4 PETERSEN POPULATION ESTIMATE**

Six assumptions must be satisfied to estimate the Atlantic tomcod population size in the Hudson River using the Petersen method or related methods (Cormack 1968, Ricker 1975, Seber 1982):

1. tagged Atlantic tomcod suffer the same mortality as untagged fish,
2. tagging does not affect Atlantic tomcod catchability,
3. tagged Atlantic tomcod do not lose their tags,
4. all tags are recognized and reported,
5. immigration and/or emigration is negligible in the study area i.e., the population is closed, and
6. tagged Atlantic tomcod are randomly distributed among untagged Atlantic tomcod or the distribution of recapture fishing effort is proportional to the abundance of fish in various river regions.

Handling mortality studies for box traps (TI 1981) addressed the first assumption (above) by providing percent mortality data which were used to adjust the number of marked Atlantic tomcod (M) in the population during each marking period. Mortality adjustments were 10% or less (Section 2.3.4.1) and were intended to compensate for differential mortality of marked and unmarked fish. Handling mortality for VI-tagged fish was tested in the 1997-1998 program and found to be comparable to the earlier handling mortality estimates for finclipped fish (NAI 1998a). Assumption 2 (above) generally is applied to tagged fish that are recaptured by entanglement gear (e.g., gill nets or trammel nets; Ricker 1975), and it is unlikely that tagged Atlantic tomcod are more or less vulnerable to capture by box traps or trawls than untagged fish because the tag is not external. Additionally, tagged Atlantic

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tomcod recaptured by trawls in the 1997-1998 survey (NAI 1998a) migrated an average of 40 river miles (64 km) or more, suggesting that swimming ability was not appreciably impaired by the tags and that they migrate along with untagged fish.

Assumptions affecting the recognition, reporting and loss of tags from marked Atlantic tomcod (Assumptions 3 and 4 above) were addressed by testing during the 1997-1998 program in which VI-tagged fish were held and observed over periods ranging from 10 to 19 weeks to observe tag loss and legibility problems (NAI 1998a). Tag retention rates and proportion of legible tags were very high, particularly for tags inserted in the right operculum (the location used for the 2003-2004 program). In 42 test fish observed over a 10-week period, both tag retention and tag legibility were 100% for tags inserted in the right operculum site.

Four finclips were encountered during the 2003-2004 program. VI tags were the primary means used to mark all fish during the 2003-2004 program, but in one sample with a very large catch on 8 January 2004 in RM 56 of the Cornwall region, 260 fish were marked with finclips. Finclips had not been used since the 1997-1998 program except for two samples with very large catches during the 2000-2001 program. All four finclip recaptures in the 2003-2004 program were from the 8 January 2004 release. Three of the four finclip recaptures were in the same river mile within six days of the release date. The fourth finclip recapture was in RM 29 of the Tappan Zee region 18 days after the release date.

Marked Atlantic tomcod apparently do not violate Assumption 5 (above) by migrating out of the Hudson River during the survey period. Relatively few fish (and no marked fish) were caught in 16 tows taken outside the Battery region during the 1985-1986 study period (NAI 1987). Incidental observations by the field crew during a striped bass trawling effort which conducted more than 89 tows in areas adjacent to the Battery region after the 1985-1986 Atlantic tomcod survey ended (21 March - 16 May 1986; NAI 1987) also suggested little emigration of Atlantic tomcod had occurred since only eight Atlantic tomcod were caught and no marked fish were observed.

In the annual Atlantic tomcod spawning stock surveys, box trap-released and trawl-recaptured Atlantic tomcod are used to satisfy Assumption 6. Separation of the mark and release effort from the recapture effort in both distance and time was used to satisfy the assumption of random mixing (Schaefer 1951, Cormack 1968, Ricker 1975). The use of one sampling gear to mark the fish and a second gear to recapture them reduces the likelihood of a consistent bias in the probability of capture (Cormack 1968, Ricker 1975).

For the Atlantic tomcod surveys up through the 1993-1994 program, the sampling weeks used to represent the marking period and the recapture period for estimating population size were chosen on the basis of stable R/M and R/C ratios in order to satisfy Assumption 6 (NAI 1990). This approach has not been feasible for defining the marking and recapture periods in several of the more recent years because the number of recaptures was too low to allow a meaningful comparison of R/M and R/C ratios among sampling weeks (those ratios were zero in some weeks). Examination of eight previous surveys of M and R/M data (the 1987-1988 through 1993-1994 and 1997-1998 surveys) showed that the weeks of stable R/M ratios included about 91-98% (mean of 95%) of the total M for the year, excluding a few weeks early and late in the box trapping season when catches (and consequently the values of M) were low. Based on this pattern, the marking period for the 2003-2004 estimate was selected as the seven-week period in which 99% of the tagged fish were released, from the week beginning 15 December 2003 through the week beginning 26 January 2004.

For determining the 2003-2004 recapture period, the historical pattern of C and R/C over the same eight previous surveys (1987-1988 through 1993-1994 and 1997-1998) was more variable, with the stable R/C period including from 57% to 100% (mean of 92%) of all trawl recaptures starting with the first week in January. The stable R/C weeks typically began with a week in which trawl catch rates began to rise after an extended period of low catches when the fish were mostly upriver. Based on this pattern, a 14-week trawl recapture period was identified for the 2003-2004 estimate, from the week beginning 5 January through the week beginning 5 April 2004. This recapture period included 93% of the trawl catch after 28 December. This trawl recapture period began three weeks after the beginning of the box trap marking period, which would allow enough time for fish to migrate at least part way downriver based on previously observed movement rates on the order of 35-40 days. The resulting population estimate was very insensitive to different choices of marking and recapture periods, as changing the periods by a week or two on either end would change the estimate by less than 5%.

The spawning estimate of the Atlantic tomcod population size in the Hudson River used fish marked in box traps north of Tappan Zee during the period of 15 December 2003 through 1 February 2004 and recaptured by trawls in the Battery during the period of 5 January through 11 April 2004 (Table 3-9). The 2003-2004 population estimate for the Atlantic tomcod spawning stock in the Hudson River was 1.7 million fish with lower and upper 95% confidence limits (Poisson) of 990,000 fish and 2.9 million fish.

### **3.5 ANNUAL TRENDS 1974-1975 TO PRESENT**

The condition and fecundity of the 2003-2004 Atlantic tomcod winter spawning population were fairly typical among recent (1982-1983 and later) surveys. The proportion of males in 2003-2004 was higher than average based on laboratory biocharacteristics samples, but lower than average based on separate male and female Petersen population estimates. The proportion of Age 2 fish was the second lowest observed among the 19 most recent years of data. Weighted mean fecundity was higher than average for both Age 1 females and Age 2 females. The timing of peak spawning during the first three weeks of January was comparable to the timing in most previous years. Atlantic tomcod CPUE in the 9 m trawl and the Petersen population estimate were both lower than average. The population estimate was the tenth lowest among the 26 annual surveys compared.

#### **3.5.1 Stock Characteristics**

##### **3.5.1.1 Age and Sex Composition**

The estimated proportion of Age 2 fish in the 2003-2004 spawning stock (2.8%; Table 3-10) was the second lowest proportion of Age 2 fish observed among the 19 surveys since 1983-1984. Males were found in greater proportion and abundance than females in 2003-2004, a pattern also observed in 1983-1984, 1990-1991, 1993-1994, 1997-1998, 1998-1999, 2000-2001, and 2002-2003. Females predominated in 1985-1986, 1987-1988, 1994-1995, and 2001-2002. Males were found in approximately equal numbers as females in 1988-1989, 1989-1990, 1991-1992, 1992-1993, 1995-1996, 1996-1997, and 1999-2000. During the years with high male:female ratios, trawl catches were typically low, increasing the relative importance of box trap data. The 2003-2004 trawl catches were not low, but they were substantially lower than the box trap catches. Atlantic tomcod surveys before 1983-1984, which relied on sex ratios derived from box trap biocharacteristics samples pooled for the entire season (NAI 1984a), also generally captured a high proportion of males, ranging from 61 to 79%

of the total population. Although a trawling program was conducted during the winter of 1982-1983, no sex ratio data were obtained. Based on the evaluation of four different methods for calculating the population sex ratio (NAI 1987), the proportion of males calculated prior to 1983-84 was probably biased by (1) the timing and movements of males and females into and out of the box trap sampling area and (2) pooling of data across the entire season to obtain a population sex ratio. The predominance of males in data from previous years can be explained as an artifact of sampling during the times when males preceded the females onto the spawning grounds and when the males lingered there after most of the females had moved into the channel and downriver.

Among the estimators previously examined (NAI 1987), the Petersen method may be the least biased by sexual segregation in the Atlantic tomcod population, since each sex is treated as a separate subpopulation. The 1988-1989 through 1997-1998 surveys adopted a recommendation from the 1985-1986 survey to use weekly or biweekly finclip codes throughout most of the sampling season to provide more specific temporal data to evaluate the exposure of each sex to the spatially separated box trap and trawl sampling efforts. Similar total population estimates among the 1983-1984 through 1997-1998 surveys derived from either the sum of separate estimates of the male and female populations (Table 3-11) or the total population (Section 3.5.3), suggest the accuracy of sex ratio estimates derived from Petersen estimates was not affected by relatively long (monthly) marking periods used in 1982-1983 and 1983-1984. During 1983-1984 through 2002-2003, the proportion of males for sex-based Petersen estimates varied between 22% and 65% and the proportion of females varied from 35% to 78%. The 2003-2004 proportion of males based on the Petersen estimates was 28%, which was lower than in most years (Table 3-11).

### **3.5.1.2 Length-Weight**

Length-weight relationships for male and female Atlantic tomcod from the 2003-2004 survey were similar to results from previous years, with predicted weights being about average (Table 3-12). Females were, on average, heavier at a given length than were males. This was true in every year at all three lengths compared (125, 175, and 225 mm).

### **3.5.1.3 Fecundity**

The fecundity-length relation determined for the 2003-2004 spawning population was similar to that of previous surveys (EA 1983; NAI 1984a, 1984b, 1987, 1988, 1990, 1991, 1992, 1994a, 1994b, 1995, 1998a, 2000, 2006a, 2006b, 2006c, 2006d; LMS 1999a, 1999b, 1999c). The predicted fecundity for female Atlantic tomcod between 125 mm and 225 mm was well within the confidence intervals for most of the previous predictions (Table 3-13).

The mean Age 1 fecundity of 21,200 eggs per female for the 2003-2004 Atlantic tomcod population (Table 3-5) was higher than average compared to previous years (EA 1983; NAI 1984a, 1984b, 1987, 1988, 1990, 1991, 1992, 1994a, 1994b, 1995, 1998a, 2000, 2006a, 2006b, 2006c, 2006d; LMS 1999a, 1999b, 1999c). Age specific mean fecundity for Age 2 females of 69,000 eggs per female (Table 3-5) was also higher than average among the years compared. The high Age 2 fecundity for 2003-2004 was due to the high proportion of Age 2 females in the larger length classes (Table 3-5).

The estimated Atlantic tomcod egg deposition of 28 billion eggs during the 2003-2004 program was about average compared to the 18 previous surveys (Table 3-14). The average egg deposition estimate in 2003-2004 was the result of lower than average population size and higher than average fecundity. Egg deposition was not compared with surveys prior to 1983-1984 because these earlier estimates were

based on sex ratios derived exclusively from box trap samples which may underestimate egg deposition due to an under-representation of female Atlantic tomcod in the box trap catch (Section 3.5.1.1).

### 3.5.2 Population Distribution During the Spawning Run

In previous surveys, relative abundance (C/H) of Atlantic tomcod in box traps has peaked in the late-December through mid-January period. In 2003-2004, C/H peaked during the week of 22 December 2003 in the West Point region. The West Point region has generally had the highest relative abundance of Atlantic tomcod during the spawning run and may be the center of spawning activity in the Hudson River (TI 1981; EA 1983; NAI 1984a, 1984b, 1987, 1988, 1990, 1991, 1992, 1994a, 1994b, 1995, 1998a, 2000, 2006a, 2006b, 2006c, 2006d; LMS 1999a, 1999b, 1999c). Relatively high C/H for Atlantic tomcod indicates that spawning activity may also be centered in the Tappan Zee and Croton-Haverstraw regions in certain years. C/H was low in the South box trap region from 1987-1988 through 1997-1998 in contrast to the 1982-1983, 1983-1984 and 1985-1986 surveys when substantial catch and spawning activity were observed in both North and South box trap regions. In 2002-2004 Croton-Haverstraw was the region contributing most to the total box trap catch, with the West Point and Cornwall regions accounting for most of the rest. The contribution of the Tappan Zee region to the total box trap catch increased in 1998-1999 (NAI 2000), but it returned to low levels in 1999-2000 and 2000-2001 (NAI 2006a, 2006b) before rebounding to higher levels in 2001-2002 (NAI 2006c), 2002-2003 (NAI 2006d), and 2003-2004 (Figure 3-2).

Atlantic tomcod spawning activity occurs in low salinity water (<15 ppt, Peterson et al. 1980). The observed inter-annual variation in the distribution of Atlantic tomcod as indicated by peaks in box trap C/H in both the South and North regions in some years, while only one C/H peak in the North region is observed in other years, was hypothesized to be related to salinity intrusion (NAI 1988). This hypothesis was evaluated by comparing predicted salinity isopleths for the river channel with weekly mean Atlantic tomcod C/H during periods of peak spawning abundance (NAI 1988). Results from this comparison for the 1974-1975 through 1987-1988 surveys were inconclusive, and it was hypothesized that the predicted, mid-channel salinity isopleths may not accurately reflect the bottom salinity experienced by Atlantic tomcod in the near-shore areas where the box traps are set. Furthermore, surface salinity measurements obtained in the box trap survey may be lower than the actual salinity experienced by Atlantic tomcod near the river bottom due to vertical stratification of saline and fresh water. Therefore, the box trap survey field methods were modified in 1988-1989 to obtain both surface and bottom conductivity (salinity) measurements, so that and the original hypothesis could be reexamined.

Mean bottom salinities observed in the weeks of peak spawning activity never exceeded 15 ppt, and observed bottom salinities were generally less than 3 ppt higher than surface salinities during 1988-1989 through 2003-2004 (Table 3-15). Bottom water salinities also never exceeded 15 ppt when the average ratio of weekly mean surface to bottom water salinities for 1988-1989, 1989-1990 and 1990-1991 were used to estimate bottom salinities for 1982-1983 through 1987-1988. A change occurred after 1985-1986 in the ratio of weekly mean Atlantic tomcod catch per hour (C/H) for the period of peak abundance in the North and South box trap regions (Table 3-15). North/South C/H ratios for the 1982-1983, 1983-1984 and 1985-1986 surveys were near one, indicating similar peak densities of Atlantic tomcod during peak spawning in both the North and South regions. Both C/H and (estimated) bottom water salinity were relatively high in the South region during 1985-1986, suggesting that

salinity intrusion does not influence Atlantic tomcod abundance during the period of peak spawning in the South region. The ratios for surveys conducted from 1987-1988 through 2000-2001 were usually much greater than one, reflecting higher weekly mean C/H in the North region than in the South region. Ratios of 0.6 in 2001-2002, 0.3 in 2002-2003, and 1.0 in 2003-2004 indicate a recent downstream shift in the location of spawning fish (Table 3-15).

### **3.5.3 Population Size**

Prior to 1982-1983, estimates of Atlantic tomcod spawning population size relied on fish finclipped or Carlin-tagged and released from box traps above the Bear Mountain Bridge (North) and recaptured in Yonkers through Indian Point (South) by box traps, impingement and a limited trawling effort (TI 1981, EA 1983). In the 1982-1983 and 1983-1984 winter surveys, trawling was conducted in the Battery region of the Hudson River (NAI 1984b). The winter trawling effort was initially implemented because of declining impingement catches and recapture rates of Atlantic tomcod at Indian Point Station (Table 3-16). Indian Point Station impingement collections of Atlantic tomcod during the winter spawning season increased to a peak during the 1978-1979 survey, and declined each year following the peak until a low point was reached in 1983-1984 (Table 3-16). Not enough Atlantic tomcod were collected in impingement at Indian Point Station after the 1982-1983 survey to provide an adequate recapture effort compared to box traps, while in years prior to 1979-1980, impingement annually contributed between 56% and 100% of the recaptured fish (Table 3-16). Trawl sampling has replaced impingement as the most important source of recaptures of marked Atlantic tomcod.

Trawl sampling in the Battery region also increased the likelihood that random mixing of marked and unmarked Atlantic tomcod has occurred prior to recapture. Random mixing of recaptured fish in the box trap catch is not likely to occur because the box traps sample the near-shore areas. Fish caught and marked in the box traps have moved upriver and inshore to spawn. Recapture proportions (R/C) from trawl sampling demonstrate that most of the Atlantic tomcod marked in box traps move downriver in the channel after spawning. Therefore, the box traps would recapture a lower proportion of marked fish by under-sampling the postspawning population.

A consequence of under-sampling the postspawning Atlantic tomcod is that mark-recapture estimates of the population size based on box trap recaptures in the South region would be biased high. Petersen population estimates based on fish finclipped and released from box traps set in the North region and recaptured in the South region using box traps were an average of 4.7 times higher compared to the corresponding estimates based on trawl recaptures of postspawning fish in the Battery (NAI 1988, 1992). The potential bias in population estimates prior to 1978-1979 may not be this high because most (56%-100%) of the Atlantic tomcod recaptured in the South region came from impingement at Indian Point Station (Table 3-16), and the withdrawal zone of the Indian Point intake includes a portion of the river channel. Atlantic tomcod population estimates reported for 1974-1975 through 1979-1980 (TI 1981) were an average of 1.6 times higher than Petersen population estimates based on fish marked and released in the North region and recaptured exclusively by Indian Point impingement (NAI 1992). In 1979-1980 and subsequent years, impingement has contributed less than 19% of the Atlantic tomcod recaptured in the South region.

The Atlantic tomcod population estimates reported prior to 1982-1983 were adjusted downward in each survey using the corresponding impingement bias adjustment (NAI 1992). Based on these adjusted population estimates, the Hudson River Atlantic tomcod population has ranged in size from

0.04 to 12.7 million fish between 1974-1975 and 2003-2004 (Table 3-17). The population was highest in 1976-1977 and 1982-1983, and lowest in 2001-2002.

### 3.5.4 Trawl Catch Per Unit of Effort as an Index of Atlantic Tomcod Abundance

Trawl catch per unit of effort (CPUE) has been considered as a potential annual index of Atlantic tomcod abundance in the lower Hudson River. Trawl CPUE is a measure of C (catch) in the Petersen mark-recapture estimator that is standardized for variation in fishing effort. If C varies in constant proportion with total population size, then CPUE can be used as a reliable index of population abundance. The CPUE index of Atlantic tomcod population abundance during the 9 m trawl recapture period exhibited a similar among-year pattern to that of the population estimates calculated by the Petersen estimator, except for 1985-1986 (Figure 3-7; Appendix Table E-8). The 1985-1986 datum was considered an outlier because the trawl CPUE index was biased high due to a more southerly distribution of the Atlantic tomcod population (NAI 1992). Linear regression of the relationship between the Atlantic tomcod population estimates and the corresponding 9 m trawl CPUE index during the recapture period for 19 of the 20 surveys from 1982-1983 to present (1985-1986 excluded) had a correlation coefficient ( $r^2$ ) of 0.890 (Figure 3-7).

Although the regression of trawl CPUE indices and Atlantic tomcod population estimates (with 1985-1986 excluded) explained 89% of the variation about the predicted line, predictions of population size based on the trawl CPUE index should be made with caution. The slope of the equation presented in Figure 3-7 is strongly influenced by one point, the high value for 1982-1983. There is a considerable gap between the 1982-1983 datum and the nearest cluster of data along the line (1989-1990, 1983-1984, and 1988-1989). The confidence interval width (precision) of the regression equation is not very different with the 1982-1983 datum ( $r^2=0.890$ ) as without it ( $r^2=0.792$ ). The 2003-2004 datum generally fit the pattern established by the earlier years. The Y-intercept for the regression using data through 1990-1991 was 2.239 million fish, and was significantly ( $p<0.05$ ) greater than zero (NAI 1992). With 13 additional years of data, the intercept was 0.578 million fish (Figure 3-7) and was not significantly different from zero ( $p<0.05$ ). Therefore, the 95% confidence bands about the regression equation now include the realistic possibility that the predicted population size is zero when the trawl CPUE index is zero. Years like 1985-1986, with an unusually high CPUE index and a southerly distribution of the Atlantic tomcod population, fall outside of the regression relationship and can only be recognized with a box trap program and a mark-recapture estimate. Thus, caution is recommended in relying on trawl CPUE to predict Atlantic tomcod population size until more empirical observations supplement the regression equation at intermediate population sizes and outliers like 1985-1986 can be reliably predicted.

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## **FIGURES**

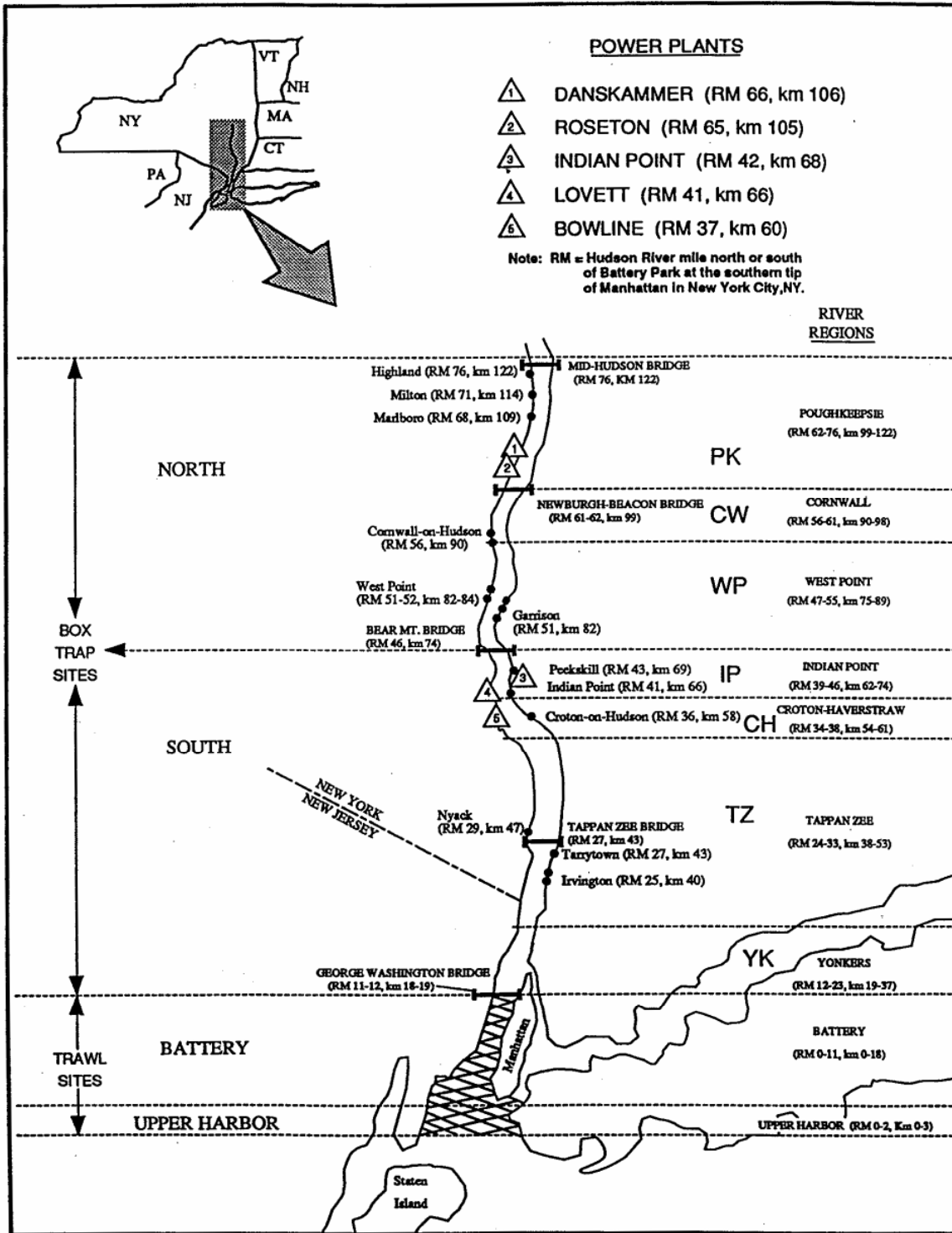


Figure 2-1. Box trap and trawl sampling sites and Hudson River regions used during the 2003-2004 Atlantic tomcod spawning survey.

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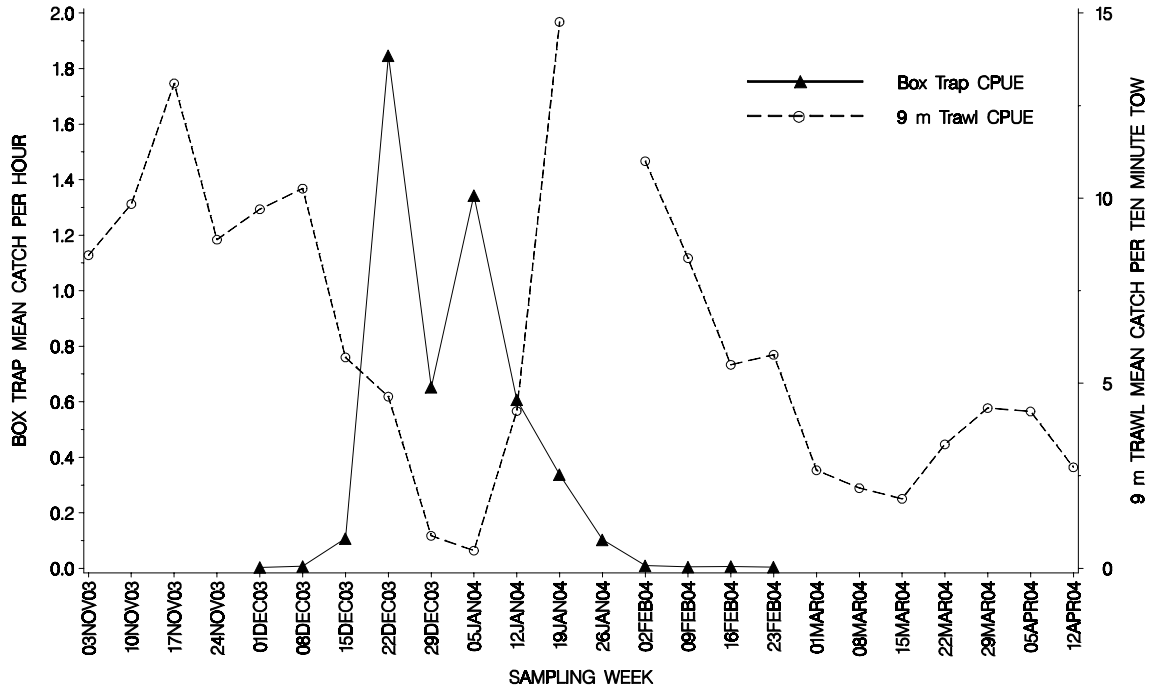


Figure 3-1. Weekly changes in Atlantic tomcod catch per unit of effort for box trap and 9 m trawl samples in the Hudson River, winter 2003-2004.

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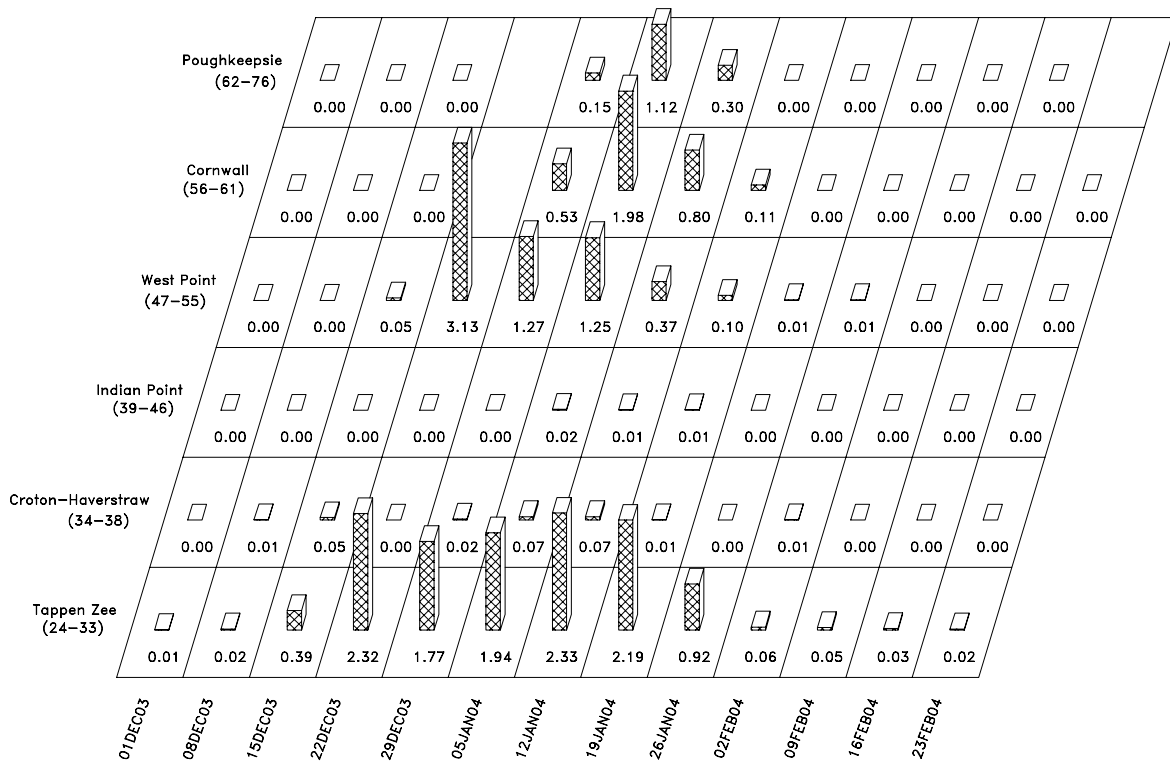


Figure 3-2. Box trap catch per hour of Atlantic tomcod in the Hudson River, winter 2003-2004.

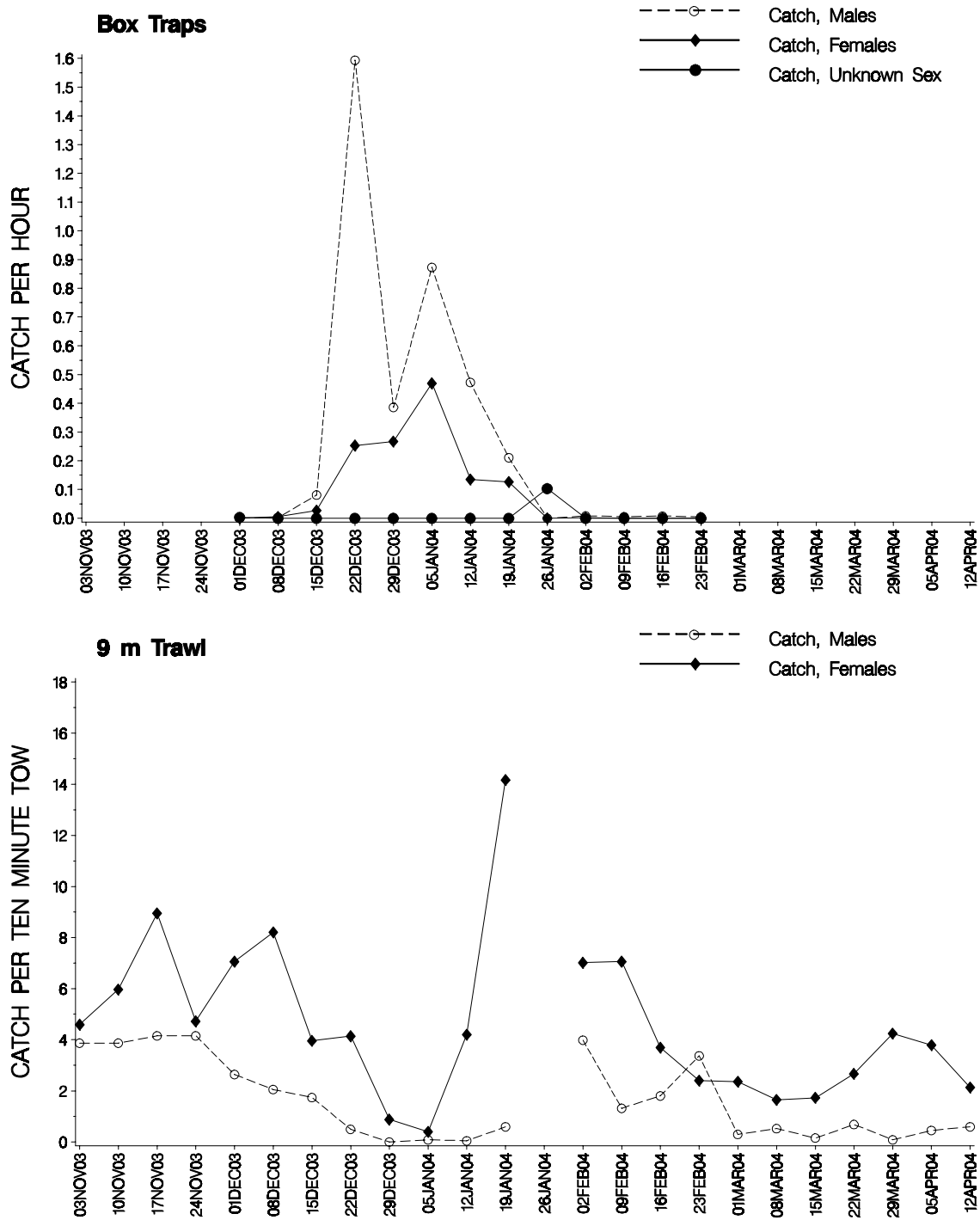


Figure 3-3. Weekly change in mean catch per unit of effort for male and female Atlantic tomcod caught by box traps or a 9 m trawl in the Hudson River, winter 2003-2004.

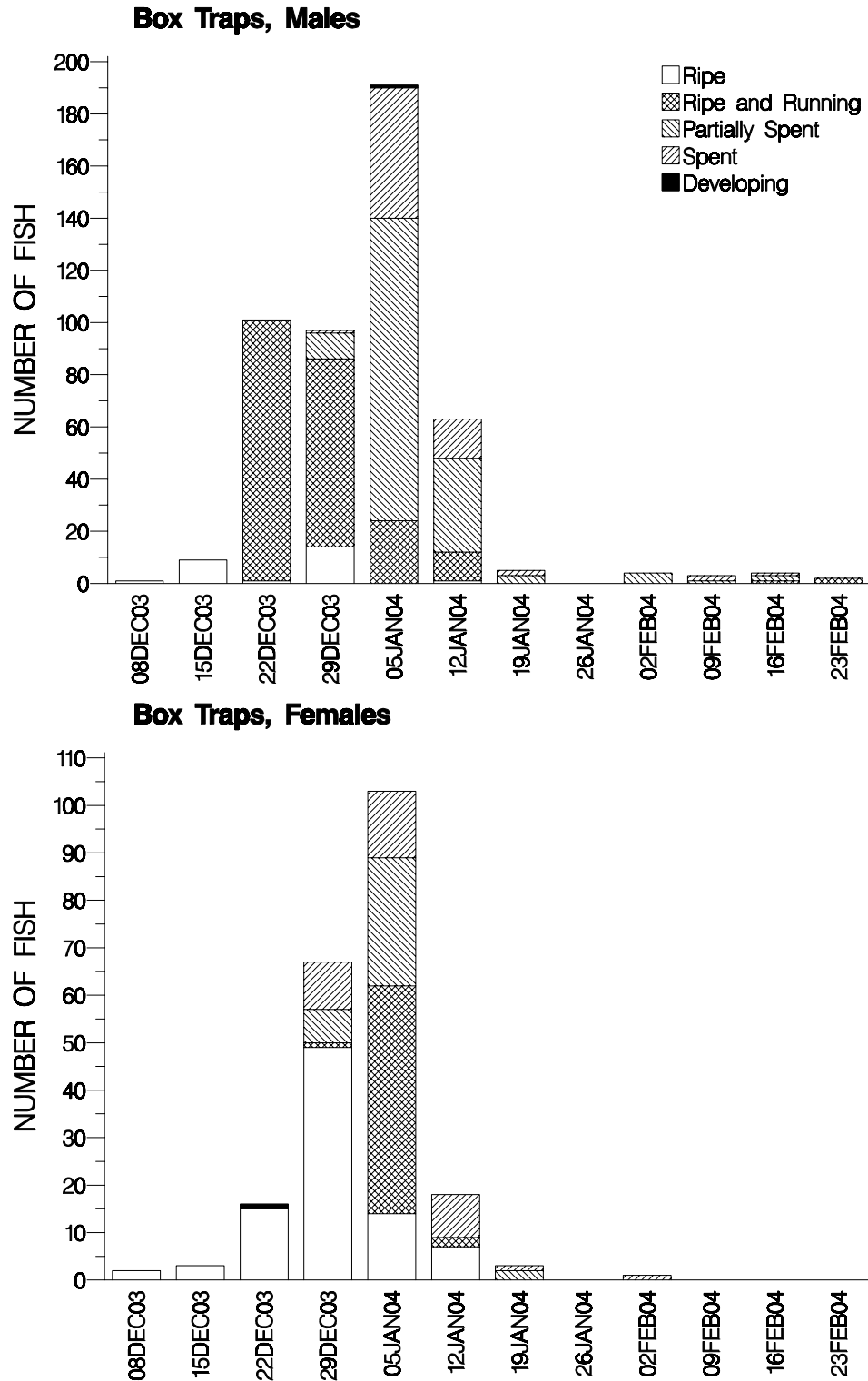


Figure 3-4. Sexual condition of male and female Atlantic tomcod in box trap biocharacteristics samples collected in the Hudson River, winter 2003-2004 (ages 1 and 2 combined).

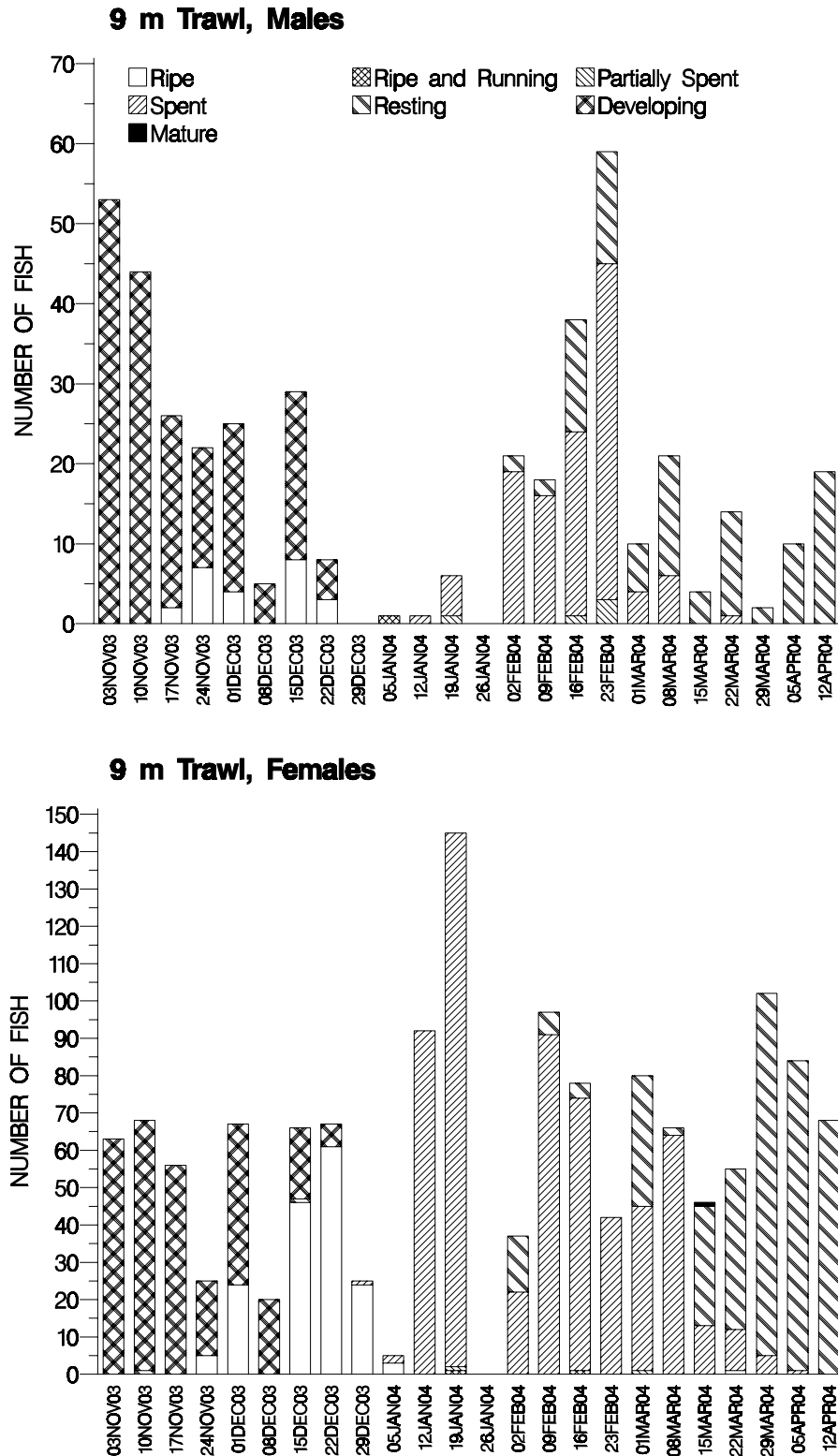


Figure 3-5. Sexual condition of male and female Atlantic tomcod in 9 m trawl biocharacteristics samples collected in the Hudson River, winter 2003-2004 (ages 1 and 2 combined).

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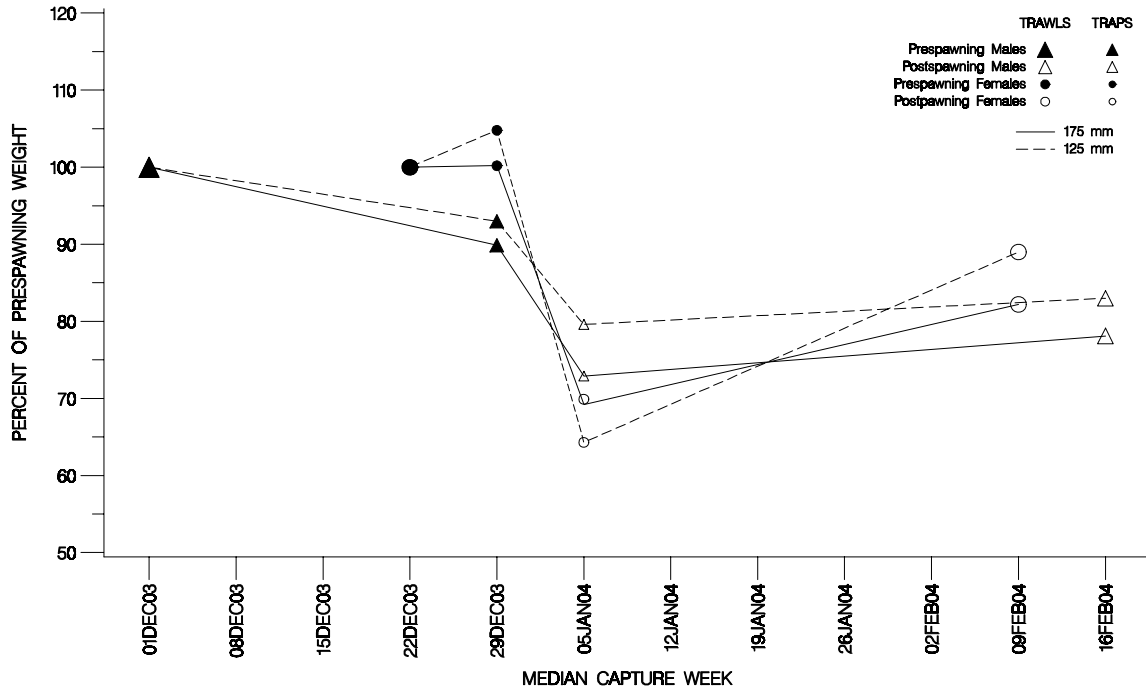


Figure 3-6. Changes in predicted weight for pre- and post-spawning male and female Atlantic tomcod caught by 9 m trawls and box traps in the Hudson River, winter 2003-2004.

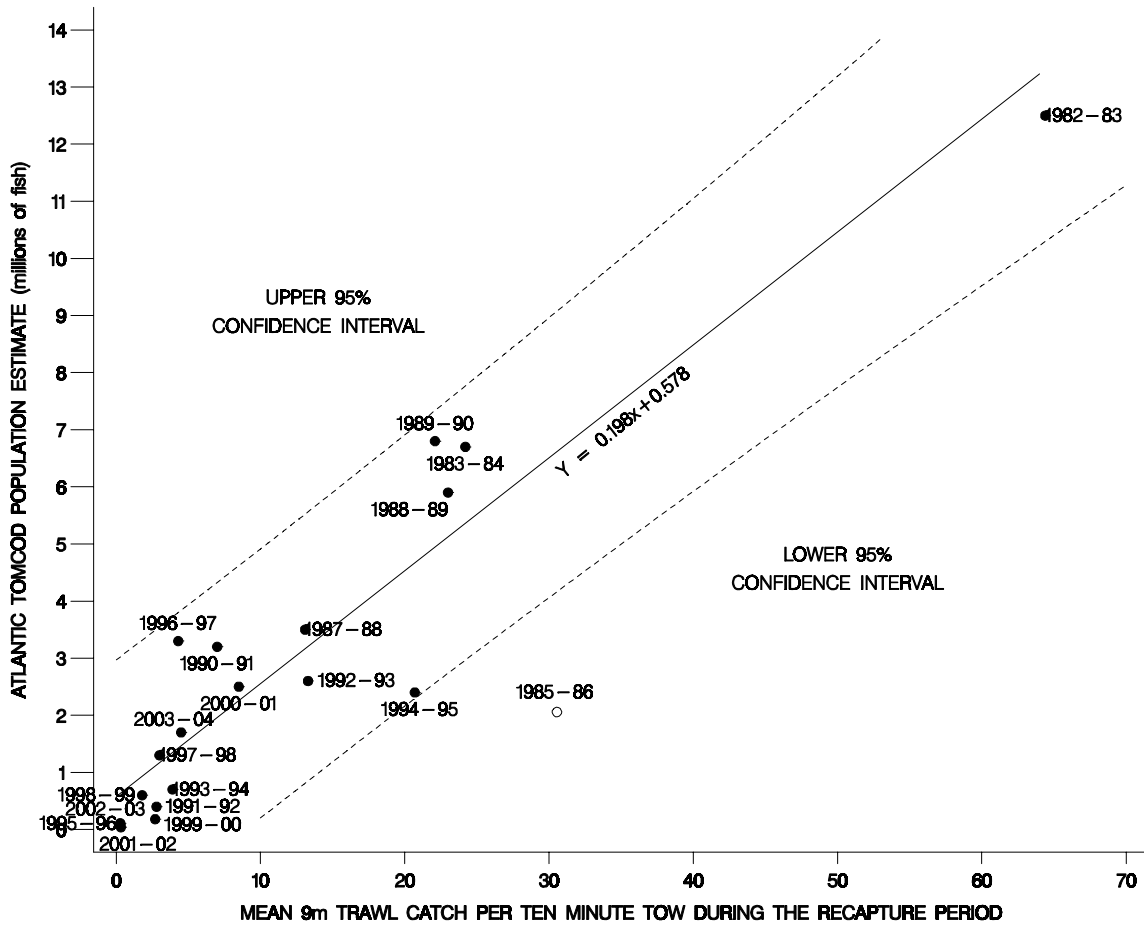


Figure 3-7. Predictive relationship between mean 9 m trawl CPUE during the recapture period and Atlantic tomcod population estimates for the 1982-1983 through 2003-2004 winter spawning surveys (1985-1986 excluded from analysis).

## **TABLES**

**Table 2-1. Standard Hudson River Box Trap Sites for Weekly Collection of Atlantic Tomcod Used in Biocharacteristics Analysis.**

River Mile	Kilometer	Site	Location
27	43	East	Tarrytown
36	58	East	Croton Yacht Club
41	66	East	Indian Point Hatchery
51	82	East	Garrison
51-52	82-84	West	West Point
56	90	West	Cornwall Yacht Club

**Table 2-2. Atlantic Tomcod Sexual Condition Criteria.**

Condition	Description
Immature	A specimen which is either male or female, but too young to spawn (sub-adult). Transparent or pinkish gonads, not developed.
Developing (Intermediate)	Applicable to sub-ripe fish heading into spawning season. Testes are opaque and reddish to reddish white. Ovaries may appear orange and eggs visible to the naked eye, granular, and whitish to orange-reddish. May or may not spawn.
Ripe	Adult in spawning condition; gonads well developed but no milt or eggs extruded upon application of pressure to gonadal area. Will spawn in current season.
Ripe and Running	Adult prepared to spawn immediately; expulsion of eggs or milt from body with little provocation.
Partially Spent	Sexual products partially discharged; gonads somewhat flaccid as opposed to the firmness of a developing gonad. Genital aperture usually inflamed, some hemorrhaging present.
Spent	Applied to adult specimens at completion of spawning activity. The sexual products have been discharged; genital aperture usually inflamed and hemorrhaging present. The gonads have the appearance of deflated sacs, the ovaries usually containing a few leftover eggs in a state of reabsorption and the testes have some residual sperm. Ovarian walls will become leathery.
Resting	Applies to adult fish with underdeveloped gonads.

**Table 2-3. Atlantic Tomcod Length Groups.**

Length Group	Millimeter Range (Total Length)
1	≤125
2	126-150
3	151-175
4	176-200
5	201-225
6	226-250
7	251-275
8	≥276

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**Table 3-1. Estimated Age and Sex Composition of Atlantic Tomcod Collected in the Hudson River during the Spawning Period, Winter 2003-2004.**

			<b>Male</b>	<b>Female</b>	<b>Sexes Combined</b>
<b>Box Traps</b>	Age 1	Number Percent	7,768 68.4	3,228 28.4	10,996 96.8
	Age 2	Number Percent	98 0.9	262 2.3	360 3.2
	Age 3	Number Percent	0 0.0	0 0.0	0 0.0
	<b>Total</b>	Number Percent	7,866 69.3	3,490 30.7	11,356 100.0
<b>9 m Trawl</b>	Age 1	Number Percent	1,137 22.9	3,726 75.1	4,863 98.0
	Age 2	Number Percent	8 0.2	92 1.9	100 2.0
	Age 3	Number Percent	0 0.0	0 0.0	0 0.0
	<b>Total</b>	Number Percent	1,145 23.1	3,818 76.9	4,963 100.0
<b>Box Traps and 9 m Trawl Combined</b>	Age 1	Number Percent	8,905 54.6	6,954 42.6	15,859 97.2
	Age 2	Number Percent	106 0.6	354 2.2	460 2.8
	Age 3	Number Percent	0 0.0	0 0.0	0 0.0
	<b>Total</b>	Number Percent	9,011 55.2	7,308 44.8	16,319 100.0

**Table 3-2. Predicted Weight for Male and Female Atlantic Tomcod Collected in the Hudson River during the Spawning Season, Winter 2003-2004.**

Total Length (mm)	Predicted Weight in Grams <sup>a</sup> (95% Confidence Limits)	
	Males	Females
125	16.7 (12.8-21.8)	17.4 (13.4-22.7)
175	43.7 (33.5-57.1)	49.7 (38.3-64.5)
225	89.9 (68.8-117.4)	108.5 (83.6-140.9)

<sup>a</sup> Predicted using the following regression equation (Appendix Table D-3):  $\log_{10} \text{ weight} = b_0 + b_1 (\log_{10} \text{ length})$ .

**Table 3-3. Comparison of Condition between Pre- and Postspawning Male and Female Atlantic Tomcod Caught by 9 m Trawls or Box Traps in the Hudson River, Winter 2003-2004.**

Sex	Gear	ANCOVA Model				Reproductive Stage	
		df	F Value	Pr>F	r <sup>2</sup>	F Value	Pr>F
Male	Box trap	94	850	<0.0001	0.95	107	<0.0001
Male	9 m trawl	149	731	<0.0001	0.91	156	<0.0001
Female	Box trap	121	1,685	<0.0001	0.97	249	<0.0001
Female	9 m trawl	819	2,593	<0.0001	0.91	596	<0.0001

**Table 3-4. Predicted Fecundity for Female Atlantic Tomcod Collected in the Hudson River during the Spawning Season, Winter 2003-2004.**

Total Length (mm)	Predicted Mean Number of Eggs per Fish <sup>a</sup> (95% Confidence Limits)
125	4,800 (3,100-7,600)
175	14,300 (9,300-22,100)
225	32,400 (21,000-49,800)

<sup>a</sup> Predicted using the following regression equation (Appendix Table D-5):  
 $\log_{10} \text{fecundity} = b_0 + b_1 (\log_{10} \text{length})$ .

**Table 3-5. Mean Fecundity Presented by 25-mm Length Group for Age 1 and Age 2 Atlantic Tomcod Collected in the Hudson River during the Spawning Season, Winter 2003-2004.**

Length Group (mm)	Age 1			Age 2		
	Mean Fecundity	Number of Females Examined	Percent Composition <sup>a</sup>	Mean Fecundity	Number of Females Examined	Percent Composition <sup>a</sup>
≤125						
126-150	6,200	1	1.1			
151-175	12,800	13	17.8			
176-200	19,000	15	47.1			
201-225	28,000	15	30.1	27,100 <sup>b</sup>	0	2.0
226-250	37,400	9	3.7	38,800 <sup>b</sup>	0	2.0
251-275	53,700 <sup>b</sup>	0	0.1	49,300	2	37.3
≥276	72,100 <sup>b</sup>	0	0.1	83,900	8	58.8
Weighted Mean Fecundity	21,200			69,000		

<sup>a</sup> Percent composition for Age 1 or Age 2 females was derived from the combined box trap and trawl biocharacteristics samples and used to weight the fecundity in each length group to calculate the mean fecundity.

<sup>b</sup> Estimated fecundities for Atlantic tomcod with lengths of 213 mm, 238 mm, 263 mm, and 288 mm, were calculated from the fecundity-length regression (Appendix Table D-5) and were used in calculating weighted mean fecundity. The first three of those lengths represent the midpoints of unsampled length groups and 288 mm was the length of the only Age 1 female in the laboratory samples for its length group.

**Table 3-6. Movement of Atlantic Tomcod Marked and Released from Box Traps and Recaptured by Trawls in the Winter 2003-2004.**

Sex	N <sup>a</sup>	Gear		Region <sup>b</sup>		Minimum Distance Moved <sup>c</sup>				Days at Large <sup>d</sup>	
		Release	Recapture	Release	Recapture	Min	Max	Mean	±S.E.	Min	Max
Combined	13	Box Trap	Trawl	YK-PK	Battery	16	58	31	4	10	87
	6	Box Trap	Trawl	North	Battery	42	58	47	2	26	87
	7	Box Trap	Trawl	South	Battery	16	24	18	1	10	57
Male	8	Box Trap	Trawl	YK-PK	Battery	16	58	30	6	24	57
	3	Box Trap	Trawl	North	Battery	42	58	49	5	26	43
	5	Box Trap	Trawl	South	Battery	16	21	18	1	24	57
Female	5	Box Trap	Trawl	YK-PK	Battery	16	44	34	6	10	87
	3	Box Trap	Trawl	North	Battery	44	44	44	0	32	87
	2	Box Trap	Trawl	South	Battery	16	24	20	4	10	37

<sup>a</sup> N = number of Atlantic tomcod recaptured.

<sup>b</sup> Region (Miles): Battery = RM 2-11 (km 3-18)  
 YK-PK = Yonkers-Poughkeepsie, RM 18-76 (km 29-122)  
 North = RM 51-76 (km 82-122)  
 South = RM 18-43 (km 29-69)

<sup>c</sup> Distance Moved: difference in river miles between the release location and the trawl recapture river mile.

<sup>d</sup> Days at Large: Number of days between the mark date and the recapture date.

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**Table 3-7. Recaptured Atlantic Tomcod Cross Classified by Release and Recapture Region in the Hudson River Estuary, Winter 2003-2004.**

Recapture Region	Number Examined for Marks (C)	Statistic	Recaptured Atlantic Tomcod from Release Region			
			North M=5,034	South M=4,837	Battery M=1,485	Total M=11,356
North (km 75-122; RM 47-76)	5,757	R	82	0	9	91
		R/M	0.01629	0.00000	0.00606	0.00801
		R/C	0.01424	0.00000	0.00156	0.01581
South (km 19-74; RM 12-46)	5,600	R	2	54	5	61
		R/M	0.00040	0.01112	0.00337	0.00537
		R/C	0.00036	0.00964	0.00089	0.01089
Battery (km 0-18; RM 0-11)	3,479	R	6	7	57	70
		R/M	0.00119	0.00144	0.03838	0.00616
		R/C	0.00172	0.00201	0.01638	0.02012
<b>Total</b>	<b>14,836</b>	<b>R</b>	<b>90</b>	<b>61</b>	<b>71</b>	<b>222</b>
		<b>R/M</b>	<b>0.01788</b>	<b>0.01256</b>	<b>0.04781</b>	<b>0.01955</b>
		<b>R/C</b>	<b>0.00607</b>	<b>0.00411</b>	<b>0.00479</b>	<b>0.01496</b>

R = number of marked Atlantic tomcod recaptured from the 2003-2004 program.

M = number of fish marked and released, adjusted for handling mortality as follows: box traps, 10.0% prior to 1 January and 2.5% on and after 1 January.

C = number of fish examined for marks. Box traps were used in North and South regions. In the Battery, trawl sampling was used to capture fish.

R/M = recapture rate.

R/C = recapture proportion.

**Table 3-8. Recaptured Atlantic Tomcod Cross-Classified by Release and Recapture Period for Fish Marked in B  
Yonkers and Recaptured in Trawls South of the George Washington Bridge in The Hudson River, Wi**

Recapture Period	Number Examined for Tags (C)	Statistic	Recaptured Atlantic Tomcod from Release Week(s) Beginning									
			1 Dec-8 Dec M = 15	15 Dec M = 224	22 Dec M = 1,433	29 Dec M = 2,494	5 Jan M = 3,635	12 Jan M = 1,424	19 Jan M = 479	26 Jan M = 147	2 Feb M = 8	
1-8 Dec	640	R	0									
		R/M	0.00000									
		R/C	0.00000									
15 Dec	202	R	0	0								
		R/M	0.00000	0.00000								
		R/C	0.00000	0.00000								
22 Dec	116	R	0	0	0							
		R/M	0.00000	0.00000	0.00000							
		R/C	0.00000	0.00000	0.00000							
29 Dec	30	R	0	0	0	0						
		R/M	0.00000	0.00000	0.00000	0.00000						
		R/C	0.00000	0.00000	0.00000	0.00000						
5 Jan	13	R	0	0	0	1	0					
		R/M	0.00000	0.00000	0.00000	0.00040	0.00000					
		R/C	0.00000	0.00000	0.00000	0.07692	0.00000					
12 Jan	95	R	0	0	0	0	0	0				
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000				
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000				
19 Jan	267	R	0	0	0	0	0	0	0			
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000			
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000			
26 Jan	0	R	0	0	0	0	0	0	0	0		
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000		
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000		
2 Feb	165	R	0	0	0	0	2	0	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00055	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.01212	0.00000	0.00000	0.00000	0.00000	0.00000



**Table 3-8. (Continued)**

Recapture Period	Number Examined for Tags (C)	Statistic	Recaptured Atlantic Tomcod from Release Week(s) Beginning								
			1 Dec-8 Dec M = 15	15 Dec M = 224	22 Dec M = 1,433	29 Dec M = 2,494	5 Jan M = 3,635	12 Jan M = 1,424	19 Jan M = 479	26 Jan M = 147	2 Feb M = 8
12 Apr	139	R	0	0	0	0	0	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
<b>Total</b>	<b>3,479</b>	<b>R</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>4</b>	<b>5</b>	<b>4</b>	<b>0</b>	<b>0</b>	<b>0</b>
		<b>R/M</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00160</b>	<b>0.00138</b>	<b>0.00281</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00000</b>
		<b>R/C</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00115</b>	<b>0.00144</b>	<b>0.00115</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00000</b>

R = number of Atlantic tomcod tagged and released from box traps north of Yonkers and recaptured from a 9 m trawl in the Battery region.

M = number of fish tagged and released from box traps north of Yonkers, adjusted for handling mortality of 10.0% prior to 1 January, and 2.5% on an

C = number of fish caught and examined for tags from a 9 m trawl in the Battery region.

R/M = recapture rate.

R/C = recapture proportion.

**Table 3-9. Atlantic Tomcod Mark-Recapture Statistics for Spawning Population Estimate in the Hudson River, Winter 2003-2004.**

<b>Statistics<sup>a</sup></b>	<b>Sampling Gear</b>	<b>Dates</b>	<b>Spawning Estimate (Trap-Trawl)</b>
Number Marked (M)	Box Traps	15 Dec – 1 Feb	9,836
Number Examined (C)	Trawls	5 Jan – 11 Apr	2,352
Number Recaptured (R)	Trawls	5 Jan – 11 Apr	13
Recapture Rate (R/M)			0.00132
Recapture Proportion (R/C)			0.00553
Petersen Population Estimate			1,700,000
Upper 95% Confidence Limit			2,900,000
Lower 95% Confidence Limit			990,000

<sup>a</sup> Statistics:

R = number of marked Atlantic tomcod recaptured.

M = number of fish marked and released, adjusted for handling mortality.

C = number of fish caught and examined for marks.

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**Table 3-10. Estimated Age and Sex Composition of Atlantic Tomcod Collected in the Hudson River, Winters of 1983-1984 through 2003-2004.**

			1983-1984 <sup>b</sup>			1985-1986 <sup>c</sup>		
			Male	Female	Sexes Combined	Male	Female	Sexes Combined
Box Traps	Age 1	Number <sup>a</sup> Percent	19,909 56.6	10,761 30.6	30,670 87.2	7,785 47.6	7,573 46.2	15,358 93.8
	Age 2	Number <sup>a</sup> Percent	3,020 8.6	1,477 4.2	4,497 12.8	513 3.1	496 3.1	1,009 6.2
	<b>Total</b>	Number <sup>a</sup> Percent	22,929 65.2	12,238 34.8	35,167 100.0	8,298 50.7	8,069 49.3	16,367 100.0
9 m Trawl	Age 1	Number <sup>a</sup> Percent	1,575 26.5	3,790 63.9	5,365 90.4	5,918 20.2	22,211 76.0	28,129 96.2
	Age 2	Number <sup>a</sup> Percent	193 3.3	375 6.3	568 9.6	259 0.9	852 2.9	1,111 3.8
	<b>Total</b>	Number <sup>a</sup> Percent	1,768 29.8	4,165 70.2	5,933 100.0	6,177 21.1	23,063 78.9	29,240 100.0
Box Traps and Trawl Combined	Age 1	Number <sup>a</sup> Percent	21,484 52.3	14,551 35.4	36,035 87.7	13,703 30.0	29,784 65.3	43,487 95.3
	Age 2	Number <sup>a</sup> Percent	3,213 7.8	1,852 4.5	5,065 12.3	772 1.7	1,348 3.0	2,120 4.7
	<b>Total</b>	Number <sup>a</sup> Percent	24,697 60.1	16,403 39.9	41,100 100.0	14,475 31.7	31,132 68.3	45,607 100.0

			1987-1988 <sup>d</sup>			1988-1989 <sup>e</sup>		
			Male	Female	Sexes Combined	Male	Female	Sexes Combined
Box Traps	Age 1	Number <sup>a</sup> Percent	7,883 51.7	5,745 37.7	13,628 89.4	33,119 60.7	15,547 28.5	48,666 89.2
	Age 2	Number <sup>a</sup> Percent	340 2.2	1,288 8.4	1,628 10.6	3,564 6.5	2,343 4.3	5,907 10.8
	<b>Total</b>	Number <sup>a</sup> Percent	8,223 53.9	7,033 46.1	15,256 100.0	36,683 67.2	17,890 32.8	54,573 100.0
9 m Trawl	Age 1	Number <sup>a</sup> Percent	3,499 26.7	8,008 61.1	11,507 87.8	3,071 11.0	22,806 81.6	25,877 92.6
	Age 2	Number <sup>a</sup> Percent	220 1.7	1,383 10.5	1,603 12.2	142 0.5	1,932 6.9	2,074 7.4
	<b>Total</b>	Number <sup>a</sup> Percent	3,719 28.4	9,391 71.6	13,110 100.0	3,213 11.5	24,738 88.5	27,951 100.0
Box Traps and Trawl Combined	Age 1	Number <sup>a</sup> Percent	11,382 40.0	13,753 48.6	25,135 88.6	36,190 43.9	38,353 46.5	74,543 90.3
	Age 2	Number <sup>a</sup> Percent	560 2.0	2,671 9.4	3,231 11.4	3,706 4.5	4,275 5.2	7,981 9.7
	<b>Total</b>	Number <sup>a</sup> Percent	11,942 42.0	16,424 58.0	28,366 100.0	39,896 48.3	42,628 51.7	82,524 100.0

(continued)

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**Table 3-10. (Continued)**

			1989-1990 <sup>f</sup>			1990-1991 <sup>g</sup>		
			Male	Female	Sexes Combined	Male	Female	Sexes Combined
Box Traps	Age 1	Number <sup>a</sup> Percent	17,985 50.2	9,480 26.5	27,465 76.7	16,354 63.4	6,046 23.4	22,400 86.8
	Age 2	Number <sup>a</sup> Percent	4,046 11.3	4,317 12.0	8,363 23.3	1,676 6.5	1,739 6.7	3,415 13.2
	<b>Total</b>	Number <sup>a</sup> Percent	22,031 61.5	13,797 38.5	35,828 100.0	18,030 69.8	7,785 30.2	25,815 100.0
9 m Trawl	Age 1	Number <sup>a</sup> Percent	5,349 21.6	13,646 55.0	18,995 76.6	1,184 16.3	5,122 70.3	6,306 86.6
	Age 2	Number <sup>a</sup> Percent	898 3.6	4,920 19.8	5,818 23.4	98 1.3	880 12.1	978 13.4
	<b>Total</b>	Number <sup>a</sup> Percent	6,247 25.2	18,566 74.8	24,813 100.0	1,282 17.6	6,002 82.4	7,284 100.0
Box Traps and Trawl Combined	Age 1	Number <sup>a</sup> Percent	23,334 38.5	23,126 38.1	46,460 76.6	17,538 53.0	11,168 33.7	28,706 86.7
	Age 2	Number <sup>a</sup> Percent	4,944 8.2	9,237 15.2	14,181 23.4	1,774 5.4	2,619 7.9	4,393 13.3
	<b>Total</b>	Number <sup>a</sup> Percent	28,278 46.6	32,363 53.4	60,641 100.0	19,312 58.3	13,787 41.7	33,099 100.0

			1991-1992 <sup>h</sup>			1992-1993 <sup>i</sup>		
			Male	Female	Sexes Combined	Male	Female	Sexes Combined
Box Traps	Age 1	Number <sup>a</sup> Percent	2,995 54.3	1,276 23.1	4,271 77.4	17,479 64.7	7,669 28.4	25,148 93.1
	Age 2	Number <sup>a</sup> Percent	570 10.3	676 12.2	1,246 22.6	490 1.8	1,367 5.1	1,857 6.9
	<b>Total</b>	Number <sup>a</sup> Percent	3,565 64.6	1,952 35.4	5,517 100.0	17,969 66.5	9,036 33.5	27,005 100.0
9 m Trawl	Age 1	Number <sup>a</sup> Percent	413 18.7	1,383 62.6	1,796 81.3	2,524 22.2	7,480 65.8	10,004 88.0
	Age 2	Number <sup>a</sup> Percent	29 1.3	385 17.4	414 18.7	41 0.4	1,318 11.6	1,359 12.0
	<b>Total</b>	Number <sup>a</sup> Percent	442 20.0	1,768 80.0	2,210 100.0	2,565 22.6	8,798 77.4	11,363 100.0
Box Traps and Trawl Combined	Age 1	Number <sup>a</sup> Percent	3,408 44.1	2,659 34.4	6,067 78.5	20,003 52.1	15,149 39.5	35,152 91.6
	Age 2	Number <sup>a</sup> Percent	599 7.8	1,061 13.7	1,660 21.5	531 1.4	2,685 7.0	3,216 8.4
	<b>Total</b>	Number <sup>a</sup> Percent	4,007 51.8	3,720 48.1	7,727 100.0	20,534 53.5	17,834 46.5	38,368 100.0

(continued)

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**Table 3-10. (Continued)**

			1993-1994 <sup>i</sup>			1994-1995 <sup>k</sup>		
			Male	Female	Sexes Combined	Male	Female	Sexes Combined
Box Traps	Age 1	Number <sup>a</sup>	7,138	1,985	9,123	5,482	3,633	9,115
		Percent	66.7	18.5	85.2	55.5	36.8	92.3
	Age 2	Number <sup>a</sup>	667	920	1,587	431	326	1,757
		Percent	6.2	8.6	14.8	4.4	33.0	76.7
	<b>Total</b>	Number <sup>a</sup>	7,805	2,905	10,710	5,913	3,959	9,872
		Percent	72.9	27.1	100.0	59.9	40.1	100.0
9 m Trawl	Age 1	Number <sup>a</sup>	440	1,150	1,590	910	4,173	5,083
		Percent	18.8	49.1	67.9	16.3	74.8	91.1
	Age 2	Number <sup>a</sup>	68	684	752	20	479	499
		Percent	2.9	29.2	32.1	0.4	8.6	8.9
	<b>Total</b>	Number <sup>a</sup>	508	1,834	2,342	930	4,652	5,582
		Percent	21.7	78.3	100.0	16.7	83.3	100.0
Box Traps and Trawl Combined	Age 1	Number <sup>a</sup>	7,578	3,135	10,713	6,392	7,806	14,198
		Percent	58.1	24.0	82.1	41.4	50.5	91.9
	Age 2	Number <sup>a</sup>	735	1,604	2,339	451	805	1,256
		Percent	5.6	12.3	17.9	2.9	5.2	8.1
	<b>Total</b>	Number <sup>a</sup>	8,313	4,739	13,052	6,843	8,611	15,454
		Percent	63.7	36.3	100.0	44.3	55.7	100.0

			1995-1996 <sup>l</sup>			1996-1997 <sup>m</sup>		
			Male	Female	Sexes Combined	Male	Female	Sexes Combined
Box Traps	Age 1	Number <sup>a</sup>	971	501	1,472	6,256	2,094	8,350
		Percent	41.6	21.5	63.1	70.5	23.6	94.0
	Age 2	Number <sup>a</sup>	300	562	862	270	257	527
		Percent	12.9	24.1	36.9	3.0	2.9	6.0
	<b>Total</b>	Number <sup>a</sup>	1,271	1,063	2,334	6,526	2,351	8,877
		Percent	54.5	45.5	100.0	73.5	26.5	100.0
9 m Trawl	Age 1	Number <sup>a</sup>	43	73	116	525	2,962	3,487
		Percent	23.4	39.6	63.0	10.9	61.7	72.7
	Age 2	Number <sup>a</sup>	15	53	68	305	1,005	1,310
		Percent	8.2	28.8	37.0	6.3	21.0	27.3
	<b>Total</b>	Number <sup>a</sup>	58	126	184	830	3,967	4,797
		Percent	31.5	68.5	100.0	17.3	82.7	100.0
Box Traps and Trawl Combined	Age 1	Number <sup>a</sup>	1,014	574	1,588	6,781	5,056	11,837
		Percent	40.3	22.8	63.1	49.6	37.0	86.6
	Age 2	Number <sup>a</sup>	315	615	930	575	1,262	1,837
		Percent	12.5	24.4	36.9	4.2	9.2	13.4
	<b>Total</b>	Number <sup>a</sup>	1,329	1,189	2,518	7,356	6,318	13,674
		Percent	52.8	47.2	100.0	53.8	46.2	100.0

(continued)

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**Table 3-10. (Continued)**

			1997-1998 <sup>a</sup>			1998-1999 <sup>o</sup>		
			Male	Female	Sexes Combined	Male	Female	Sexes Combined
Box Traps	Age 1	Number <sup>a</sup> Percent	8,535 56.2	2,684 17.7	11,219 73.9	2,987 65.4	751 16.4	3,738 81.8
	Age 2	Number <sup>a</sup> Percent	1,217 8.0	2,746 18.1	3,963 26.1	288 6.3	543 11.9	831 18.2
	<b>Total</b>	Number <sup>a</sup> Percent	9,752 64.2	5,430 35.8	15,182 100.0	3,275 71.7	1,294 28.3	4,569 100.0
9 m Trawl	Age 1	Number <sup>a</sup> Percent	534 18.7	1,443 50.4	1,977 69.1	168 15.6	708 65.9	876 81.6
	Age 2	Number <sup>a</sup> Percent	48 1.7	838 29.3	886 30.9	3 0.3	195 18.2	198 18.4
	<b>Total</b>	Number <sup>a</sup> Percent	582 20.3	2,281 79.7	2,863 100.0	171 15.9	903 84.1	1,074 100.0
Box Traps and Trawl Combined	Age 1	Number <sup>a</sup> Percent	9,069 50.3	4,127 22.9	13,196 73.1	3,155 55.9	1,459 25.9	4,614 81.8
	Age 2	Number <sup>a</sup> Percent	1,265 7.0	3,584 19.9	4,849 26.9	291 5.2	738 13.1	1,029 18.2
	<b>Total</b>	Number <sup>a</sup> Percent	10,334 57.3	7,711 42.7	18,045 100.0	3,446 61.1	2,197 38.9	5,643 100.0

			1999-2000 <sup>p</sup>			2000-2001 <sup>q</sup>		
			Male	Female	Sexes Combined	Male	Female	Sexes Combined
Box Traps	Age 1	Number <sup>a</sup> Percent	1,054 61.4	367 21.4	1,421 82.8	9,061 76.3	2,529 21.3	11,590 97.6
	Age 2	Number <sup>a</sup> Percent	80 4.7	215 12.5	295 17.2	81 0.7	203 1.7	284 2.4
	<b>Total</b>	Number <sup>a</sup> Percent	1,134 66.1	582 33.9	1,716 100.0	9,142 77.0	2,732 23.0	11,874 100.0
9 m Trawl	Age 1	Number <sup>a</sup> Percent	311 28.1	737 66.6	1,048 94.8	1,146 25.7	3,114 69.8	4,260 95.5
	Age 2	Number <sup>a</sup> Percent	5 0.5	53 4.8	58 5.2	10 0.2	190 4.3	200 4.5
	<b>Total</b>	Number <sup>a</sup> Percent	316 28.6	790 71.4	1,106 100.0	1,156 25.9	3,304 74.1	4,460 100.0
Box Traps and Trawl Combined	Age 1	Number <sup>a</sup> Percent	1,365 48.4	1,104 39.1	2,469 87.5	10,207 62.5	5,643 34.5	15,850 97.0
	Age 2	Number <sup>a</sup> Percent	85 3.0	268 9.5	353 12.5	91 0.6	393 2.4	484 3.0
	<b>Total</b>	Number <sup>a</sup> Percent	1,450 51.4	1,372 48.6	2,822 100.0	10,298 63.0	6,036 37.0	16,334 100.0

(continued)

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**Table 3-10. (Continued)**

			2001-2002 <sup>r</sup>			2002-2003 <sup>s</sup>		
			Male	Female	Sexes Combined	Male	Female	Sexes Combined
Box Traps	Age 1	Number <sup>a</sup> Percent	164 40.0	205 50.0	369 90.0	971 79.1	233 19.0	1,204 98.0
	Age 2	Number <sup>a</sup> Percent	16 3.9	25 6.1	41 10.0	8 0.7	16 1.3	24 2.0
	<b>Total</b>	Number <sup>a</sup> Percent	180 43.9	230 56.1	410 100.0	979 79.7	249 20.3	1,228 100.0
9 m Trawl	Age 1	Number <sup>a</sup> Percent	32 23.0	72 51.8	104 74.8	45 33.8	87 65.4	132 99.2
	Age 2	Number <sup>a</sup> Percent	2 1.4	33 23.7	35 25.2	0 0.0	1 0.8	1 0.8
	<b>Total</b>	Number <sup>a</sup> Percent	34 24.5	105 75.5	139 100.0	45 33.8	88 66.2	133 100.0
Box Traps and Trawl Combined	Age 1	Number <sup>a</sup> Percent	196 35.7	277 50.5	473 86.2	1,016 74.7	320 23.5	1,336 98.2
	Age 2	Number <sup>a</sup> Percent	18 3.3	58 10.6	76 13.8	8 0.6	17 1.2	25 1.8
	<b>Total</b>	Number <sup>a</sup> Percent	214 39.0	335 61.0	549 100.0	1,024 75.2	337 24.8	1,361 100.0

			2003-2004		
			Male	Female	Sexes Combined
Box Traps	Age 1	Number <sup>a</sup> Percent	7,768 68.4	3,228 28.4	10,996 96.8
	Age 2	Number <sup>a</sup> Percent	98 0.9	262 2.3	360 3.2
	<b>Total</b>	Number <sup>a</sup> Percent	7,866 69.3	3,490 30.7	11,356 100.0
9 m Trawl	Age 1	Number <sup>a</sup> Percent	1,137 22.9	3,726 75.1	4,863 98.0
	Age 2	Number <sup>a</sup> Percent	8 0.2	92 1.9	100 2.0
	<b>Total</b>	Number <sup>a</sup> Percent	1,145 23.1	3,818 76.9	4,963 100.0
Box Traps and Trawl Combined	Age 1	Number <sup>a</sup> Percent	8,905 54.6	6,954 42.6	15,859 97.2
	Age 2	Number <sup>a</sup> Percent	106 0.6	354 2.2	460 2.8
	<b>Total</b>	Number <sup>a</sup> Percent	9,011 55.2	7,308 44.8	16,319 100.0

<sup>a</sup> Number = estimated number caught, excluding Age 3 fish.

<sup>b</sup> NAI 1984b

<sup>c</sup> NAI 1987

<sup>d</sup> NAI 1988

<sup>e</sup> NAI 1990

<sup>f</sup> NAI 1991

<sup>g</sup> NAI 1992

<sup>h</sup> NAI 1994a

<sup>i</sup> NAI 1994b

<sup>j</sup> NAI 1995

<sup>k</sup> LMS 1999a

<sup>l</sup> LMS 1999b

<sup>m</sup> LMS 1999c

<sup>n</sup> NAI 1998a

<sup>o</sup> NAI 2000

<sup>p</sup> NAI 2006a

<sup>q</sup> NAI 2006b

<sup>r</sup> NAI 2006c

<sup>s</sup> NAI 2006d

**Table 3-11. Estimated Population Size and Proportions for Male and Female Atlantic Tomcod in the Hudson River Specific Petersen Estimates, Winters of 1983-1984 through 2003-2004.**

Spawning Survey	Atlantic Tomcod Population Size with 95% Confidence Limits in Millions									Proportion Males
	Males			Females			Total <sup>a</sup>			
	Lower	Estimate	Upper	Lower	Estimate	Upper	Lower <sup>b</sup>	Estimate	Upper <sup>b</sup>	
1983-1984	1.32	2.16	3.72	2.10	3.70	7.13	3.42	5.86	10.85	0
1985-1986	0.48	0.61	0.79	1.08	1.33	1.64	1.56	1.94	2.43	0
1987-1988	0.79	1.29	2.22	1.31	1.95	3.03	2.10	3.24	5.25	0
1988-1989	1.53	2.12	3.01	1.65	2.03	2.50	3.18	4.15	5.51	0
1989-1990	1.54	2.38	3.87	2.44	4.31	8.32	3.98	6.69	12.19	0
1990-1991	0.44	0.77	1.49	0.98	1.58	2.70	1.42	2.35	4.19	0
1991-1992	0.06	0.11	0.23	0.10	0.17	0.31	0.16	0.28	0.54	0
1992-1993	0.67	0.93	1.33	0.92	1.31	1.95	1.59	2.24	3.28	0
1993-1994	0.17	0.36	0.83	0.11	0.19	0.36	0.28	0.55	1.19	0
1994-1995	0.26	0.54	1.25	0.65	1.31	2.84	1.07	1.85	3.47	0
1995-1996	0.01 <sup>c</sup>	0.04 <sup>c</sup>	0.07 <sup>c</sup>	0.01 <sup>c</sup>	0.05 <sup>c</sup>	0.09 <sup>c</sup>	0.03	0.09	0.16	0
1996-1997	0.22	0.71	1.29	0.28	0.92	1.67	0.50	1.63	2.96	0
1997-1998	0.22	0.46	1.05	0.34	0.59	1.10	0.56	1.05	2.15	0
1998-1999	0.04	0.14	0.25	0.06	0.16	0.39	0.10	0.29	0.64	0
1999-2000	0.02	0.05	0.14	0.03	0.06	0.16	0.05	0.12	0.30	0
2000-2001	0.46	0.81	1.56	0.46	1.04	2.59	0.92	1.84	4.15	0
2001-2002	<0.01	<0.01	— <sup>d</sup>	<0.01	0.02	— <sup>d</sup>	<0.01	0.02	— <sup>d</sup>	0
2002-2003	0.01	0.03	— <sup>d</sup>	<0.01	0.02	— <sup>d</sup>	0.01	0.05	— <sup>d</sup>	0
2003-2004	0.20	0.37	0.76	0.46	0.96	2.22	0.65	1.34	2.98	0

<sup>a</sup> Total population estimates were based on the sum of independent male and female Petersen population estimates.

<sup>b</sup> The upper and lower 95% confidence limits about the total are based on the sum of independent male and female Petersen population estimates, and are not necessarily the same as those presented.

<sup>c</sup> Estimated directly from proportion of male and female Atlantic tomcod collected in combined trawl and box trap samples. Sex-specific Petersen estimates were used.

<sup>d</sup> A meaningful upper confidence limit could not be calculated because there were fewer than two recaptures.

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**Table 3-12. Predicted Weight for Male and Female Atlantic Tomcod Collected in the Hudson River during the Spawning Season, Winters of 1980-1981 through 2003-2004.**

Year <sup>a</sup>	Total Length (mm)	Predicted Weight In Grams (95% Confidence Limits) <sup>b</sup>	
		Males	Females
1980-1981	125	14.8	16.5
	175	44.4	49.4
	225	101.0	112.0
1981-1982	125	14.4	16.6
	175	42.3	49.7
	225	94.5	112.7
1982-1983	125	13.4	16.5
	175	38.4	48.0
	225	84.3	106.5
1983-1984	125	14.3 (11.2- 18.1)	16.2 (11.7- 22.5)
	175	41.2 (32.4- 52.3)	46.8 (33.8- 64.9)
	225	90.8 (71.5-115.4)	103.3 (74.5-143.2)
1985-1986	125	15.0 (9.2- 24.3)	16.6 (10.1- 27.6)
	175	43.4 (26.2- 72.0)	49.2 (29.2- 82.8)
	225	96.2 (57.0-162.1)	110.6 (64.9-188.5)
1987-1988	125	14.4 (10.9- 19.1)	15.1 (11.1- 20.7)
	175	41.5 (31.3- 55.1)	47.0 (34.3- 64.2)
	225	91.5 (69.0-121.4)	109.4 (79.9-149.6)
1988-1989	125	14.4 (11.3- 18.3)	15.6 (11.9- 20.3)
	175	40.8 (31.9- 52.4)	45.3 (34.3- 59.7)
	225	89.0 (69.1-115.0)	100.7 (75.8-133.6)
1989-1990	125	15.6 (12.0- 20.1)	16.4 (12.2- 21.9)
	175	43.5 (33.7- 56.3)	47.2 (35.3- 63.2)
	225	93.8 (72.6-121.3)	104.3 (77.9-139.6)
1990-1991	125	14.6 (11.3- 18.8)	16.8 (12.4- 22.7)
	175	43.7 (33.8- 56.5)	49.9 (37.0- 67.4)
	225	99.4 (76.9-128.4)	112.7 (83.5-152.0)
1991-1992	125	14.5 (11.1- 18.9)	16.4 (12.6- 21.5)
	175	43.2 (33.2- 56.2)	49.9 (38.2- 65.1)
	225	97.6 (75.0-127.0)	114.3 (87.6-149.2)
1992-1993	125	14.6 (11.3- 18.8)	16.6 (12.4- 22.3)
	175	41.3 (32.1- 53.1)	47.0 (35.1- 62.9)
	225	89.7 (69.7-115.4)	102.0 (76.1-136.6)
1993-1994	125	14.8 (11.6- 18.9)	16.3 (12.0- 22.3)
	175	42.4 (33.3- 54.0)	48.0 (35.2- 65.4)
	225	93.0 (73.0-118.5)	107.4 (78.8-146.4)
1994-1995	125	13.7 (11.4-18.2)	15.4 (10.9-21.8)
	175	40.5 (28.7-45.6)	45.9 (32.5-64.8)
	225	91.0 (72.1-114.7)	103.7 (72.4-144.4)
1995-1996	125	15.9 (15.1-16.8)	19.0 (17.6-20.5)
	175	45.1 (44.3-45.9)	54.1 (52.1-56.1)
	225	98.2 (95.4-101.0)	118.1 (115.6-120.6)
1996-1997	125	15.7 (15.4-16.0)	18.0 (17.7-18.2)
	175	42.6 (42.1-43.2)	50.6 (50.3-50.9)
	225	90.1 (87.8-92.4)	109.6 (108.7-110.5)
1997-1998	125	15.5 (11.3-21.4)	16.4 (12.1-22.1)
	175	42.6 (30.9-58.6)	48.0 (35.5-64.9)
	225	90.3 (65.5-124.4)	107.2 (79.3-144.8)

(continued)

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Table 3-12 (Continued)

Year <sup>a</sup>	Total Length (mm)	Predicted Weight In Grams (95% Confidence Limits) <sup>b</sup>	
		Males	Females
1998-1999	125	14.3 (10.0-20.5)	17.2 (12.6-23.4)
	175	41.1 (28.8 (58.5)	50.0 (36.8-67.8)
	225	90.1 (63.1-128.7)	110.9 (81.7-150.5)
1999-2000	125	16.7 (12.5-22.4)	19.7 (14.3-27.3)
	175	44.7 (33.7-59.4)	54.0 (39.3-74.1)
	225	93.1 (70.0-123.9)	114.4 (83.4-157.0)
2000-2001	125	14.6 (11.4-18.6)	16.5 (12.3-22.2)
	175	42.5 (33.2-54.3)	48.4 (36.0-65.0)
	225	94.5 (73.9-120.8)	107.8 (80.1-145.0)
2001-2002	125	16.1 (12.1-21.6)	18.2 (13.7-24.2)
	175	46.9 (36.4-60.4)	54.4 (41.4-71.4)
	225	103.9 (80.4-134.3)	123.3 (94.2-161.3)
2002-2003	125	12.9 (10.2-16.4)	18.5 (12.7-27.0)
	175	39.9 (31.7-50.0)	50.7 (35.9-71.7)
	225	92.5 (73.2-116.7)	107.8 (76.5-152.1)
2003-2004	125	16.7 (12.8-21.8)	17.4 (13.4-22.7)
	175	43.7 (33.5-57.1)	49.7 (38.3-64.5)
	225	89.9 (68.8-117.4)	108.5 (83.6-140.9)

<sup>a</sup> Surveys were not conducted in 1984-1985 or 1986-1987

<sup>b</sup> Data sources (confidence limits not reported for earlier years):

1980-1981: EA (1983)  
 1981-1982: EA (1983)  
 1982-1983: NAI (1984a)  
 1983-1984: NAI (1984b)  
 1985-1986: NAI (1987)  
 1987-1988: NAI (1988)  
 1988-1989: NAI (1990)  
 1989-1990: NAI (1991)  
 1990-1991: NAI (1992)  
 1991-1992: NAI (1994a)  
 1992-1993: NAI (1994b)

1993-1994: NAI (1995)  
 1994-1995: LMS (1999a)  
 1995-1996: LMS (1999b)  
 1996-1997: LMS (1999c)  
 1997-1998: NAI (1998a)  
 1998-1999: NAI (2000)  
 1999-2000: NAI (2006a)  
 2000-2001: NAI (2006b)  
 2001-2002: NAI (2006c)  
 2002-2003: NAI (2006d)

**Table 3-13. Predicted Fecundity for Female Atlantic Tomcod Collected in the Hudson River during the Spawning Season, Winters of 1980-1981 through 2003-2004.**

<b>Year<sup>a</sup></b>	<b>Total Length (mm)</b>	<b>Predicted Mean Number of Eggs per Fish (95% Confidence Limits)<sup>b</sup></b>
1980-1981	125	6,200
	175	7,000
	225	36,200
1981-1982	125	4,000
	175	11,500
	225	25,100
1982-1983	125	4,100
	175	12,100
	225	27,400
1983-1984	125	5,200 ( 3,600-7,600)
	175	14,900 (10,200-21,700)
	225	32,600 (22,300-47,000)
1985-1986	125	4,900 ( 1,200-24,200)
	175	14,400 ( 3,300-74,300)
	225	32,000 ( 7,100-171,800)
1987-1988	125	4,800 ( 3,100-7,500)
	175	15,400 ( 9,900-23,900)
	225	36,900 (24,100-58,100)
1988-1989	125	4,100 ( 400-40,600)
	175	12,000 ( 1,100-127,900)
	225	27,000 ( 2,400-301,400)
1989-1990	125	5,100 ( 2,300-11,200)
	175	13,400 ( 6,200-29,000)
	225	27,500 (12,700-59,400)
1990-1991	125	5,200 ( 2,800-9,500)
	175	14,800 ( 8,200-27,000)
	225	32,600 (17,900-59,400)
1991-1992	125	4,300 ( 2,300-8,000)
	175	13,400 ( 8,000-23,800)
	225	31,200 (17,700-54,800)
1992-1993	125	4,800 ( 3,000-7,600)
	175	13,600 ( 8,600-21,600)
	225	29,800 (18,800-47,300)
1993-1994	125	4,500 ( 2,900-7,200)
	175	14,200 ( 9,100-22,400)
	225	33,500 (21,300-52,700)
1994-1995	125	4,400 ( 2,600-7,400)
	175	12,800 ( 7,700-21,100)
	225	28,200 (16,800-46,000)
1995-1996	125	4,900 ( 3,900-6,400)
	175	15,000 (13,300-17,100)
	225	34,600 (32,300-37,200)
1996-1997	125	4,900 ( 4,200-5,700)
	175	14,200 (13,200-15,300)
	225	31,400 (29,000-34,000)

(continued)

**Table 3-13. (Continued)**

<b>Year<sup>a</sup></b>	<b>Total Length (mm)</b>	<b>Predicted Mean Number of Eggs per Fish (95% Confidence Limits)<sup>b</sup></b>
1997-1998	125	5,700 ( 3,800-8,500)
	175	15,000 (10,100-22,400)
	225	31,000 (20,800-46,200)
1998-1999	125	4,500 ( 2,500-8,100)
	175	14,000 ( 8,000-24,300)
	225	32,700 (18,900-56,600)
1999-2000	125	2,400 (1,000-5,600)
	175	9,500 (4,500-20,200)
	225	27,100 (13,200-55,500)
2000-2001	125	4,300 (1,800-10,300)
	175	13,500 (5,800-31,600)
	225	31,600 (13,400-74,200)
2001-2002	125	4,900 (2,900-8,200)
	175	14,400 (9,100-22,600)
	225	32,200 (20,700-50,100)
2002-2003	125	4,100 (2,100-8,300)
	175	14,100 (8,300-23,900)
	225	35,400 (20,700-60,400)
2003-2004	125	4,800 (3,100-7,600)
	175	14,300 (9,300-22,100)
	225	32,400 (21,000-49,800)

<sup>a</sup> Surveys were not conducted in 1984-1985 or 1986-1987

<sup>b</sup> Data sources (confidence limits not reported for earlier years):

- |                        |                        |
|------------------------|------------------------|
| 1980-1981: EA (1983)   | 1993-1994: NAI (1995)  |
| 1981-1982: EA (1983)   | 1994-1995: LMS (1999a) |
| 1982-1983: NAI (1984a) | 1995-1996: LMS (1999b) |
| 1983-1984: NAI (1984b) | 1996-1997: LMS (1999c) |
| 1985-1986: NAI (1987)  | 1997-1998: NAI (1998a) |
| 1987-1988: NAI (1988)  | 1998-1999: NAI (2000)  |
| 1988-1989: NAI (1990)  | 1999-2000: NAI (2006a) |
| 1989-1990: NAI (1991)  | 2000-2001: NAI (2006b) |
| 1990-1991: NAI (1992)  | 2001-2002: NAI (2006c) |
| 1991-1992: NAI (1994a) | 2002-2003: NAI (2006d) |
| 1992-1993: NAI (1994b) |                        |

**Table 3-14. Estimated Population Egg Deposition for Age 1 and Age 2 Atlantic Tomcod in the Hudson River, Winter through 2003-2004.**

Spawning Survey	Atlantic Tomcod Population Size (Millions) <sup>a</sup>	Proportion Females <sup>b</sup>	Age 1			Age 2		
			Proportion Age 1 <sup>c</sup>	Weighted Mean Fecundity <sup>d</sup>	Egg Deposition (Billions) <sup>e</sup>	Proportion Age 2 <sup>c</sup>	Weighted Mean Fecundity <sup>d</sup>	Egg Deposition (Billions)
1983-1984	6.7	0.63	0.887	14,100	53	0.113	46,100	22
1985-1986	2.1	0.69	0.957	16,700	23	0.043	37,900	2
1987-1988	3.5	0.60	0.837	16,200	28	0.163	44,600	15
1988-1989	5.9	0.49	0.900	12,400	32	0.100	32,500	9
1989-1990	6.8	0.64	0.715	14,700	46	0.285	33,400	41
1990-1991	3.2	0.67	0.810	18,600	32	0.190	48,100	20
1991-1992	0.4	0.59	0.715	22,500	4	0.285	53,100	3
1992-1993	2.6	0.59	0.849	14,200	18	0.151	52,700	12
1993-1994	0.7	0.35	0.662	15,800	3	0.338	50,500	4
1994-1995	2.4	0.71	0.907	16,200	25	0.093	38,000	6
1995-1996	0.09	0.55 <sup>g</sup>	0.483	24,000	0.6	0.517	62,600	1.6
1996-1997	3.3	0.56	0.800	19,600	30	0.200	45,400	17
1997-1998	1.3	0.56	0.535	16,400	6	0.465	51,100	17
1998-1999	0.6	0.53	0.664	18,900	4	0.336	60,600	6
1999-2000	0.2	0.54	0.805	21,700	2	0.195	74,800	1
2000-2001	2.5	0.56	0.935	15,800	21	0.065	80,900	7
2001-2002	0.041	0.78	0.827	26,000	0.7	0.173	76,600	0.4
2002-2003	0.11	0.40	0.950	25,100	1	0.050	82,800	0.2
2003-2004	1.7	0.72	0.952	21,200	24	0.048	69,000	4

<sup>a</sup> Petersen estimate of the spawning population from fish marked and released in box traps and recaptured in trawls.

<sup>b</sup> From the proportion of separate Petersen estimates of male and female subpopulations using the same release and recapture periods and gear as was used.

<sup>c</sup> From laboratory biocharacteristics data for females, pooled across all weeks in the sampling season and across box traps and trawls, excluding Age 3.

<sup>d</sup> Mean fecundity by 25 mm length group within each age weighted by the total number of fish caught in each 25 mm length group, box traps and trawls.

<sup>e</sup> Egg Deposition = population size x proportion females x proportion Age 1 or 2 x weighted mean fecundity.

<sup>f</sup> Population Egg Deposition = Age 1 egg deposition + Age 2 egg deposition.

<sup>g</sup> Estimated directly from proportion of male and female Atlantic tomcod collected in trawl and box trap samples combined.

**Table 3-15. Maximum Weekly Mean Atlantic Tomcod Catch Per Hour (C/H) and Salinity Observed during the W Spawning Activity in the North and South Hudson River Box Trap Regions, 1982-1983 through 2003-2**

Survey	Weeks of Peak Spawning	Depth	Maximum Weekly Mean Salinity (ppt) in Region		Maximum Weekly M	
			North	South	North	South
1982-1983	3 Jan–24 Jan	Surface	1.2	6.4	4.3	4.0
		Bottom <sup>a</sup>	1.5	8.1		
1983-1984	19 Dec–9 Jan	Surface	0.1	3.6	6.2	4.8
		Bottom <sup>a</sup>	0.1	4.6		
1985-1986	23 Dec–13 Jan	Surface	1.1	11.1	4.2	4.5
		Bottom <sup>a</sup>	1.4	14.0		
1987-1988	21 Dec–4 Jan	Surface	0.4	9.5	3.3	0.8
		Bottom <sup>a</sup>	0.5	12.0		
1988-1989	19 Dec–9 Jan	Surface	2.3	9.4	14.7	2.6
		Bottom	3.3	12.9		
1989-1990	18 Dec–8 Jan	Surface	4.9	10.5	13.0	1.5
		Bottom	5.8	13.1		
1990-1991	31 Dec–14 Jan	Surface	1.6	8.4	5.0	1.4
		Bottom	2.0	9.2		
1991-1992	23 Dec–30 Dec	Surface	0.4	8.5	1.7	0.5
		Bottom	0.4	9.1		
1992-1993	28 Dec–4 Jan	Surface	0.1	7.2	6.2	0.6
		Bottom	0.1	7.3		
1993-1994	27 Dec–3 Jan	Surface	0.1	5.2	6.2	3.0
		Bottom	0.2	6.0		
1994-1995	2Jan–9 Jan	Surface	0.1	2.3	3.8	0.9
		Bottom	0.1	2.4		
1995-1996	25 Dec–8 Jan	Surface	0.4	4.3	2.8	0.1
		Bottom	0.4	4.4		
1996-1997	6 Jan–13 Jan	Surface	0.1	3.4	1.8	0.2
		Bottom	0.1	3.5		
1997-1998	22 Dec–5 Jan	Surface	1.3	13.3	5.0	0.1
		Bottom	1.5	13.5		
1998-1999	28 Dec–11 Jan	Surface	1.1	7.2	0.7	0.4
		Bottom	1.2	8.7		
1999-2000	27 Dec–3 Jan	Surface	0.2	4.6	0.5	0.1
		Bottom	0.3	6.2		
2000-2001	25 Dec–8 Jan	Surface	0.4	12.0	3.9	2.4
		Bottom	0.4	12.9		
2001-2002	7 Jan–14 Jan	Surface	1.9	9.0	0.1	0.2
		Bottom	2.5	10.0		

**Table 3-15. (Continued)**

Survey	Weeks of Peak Spawning	Depth	Maximum Weekly Mean Salinity (ppt) in Region		Maximum Weekly M	
			North	South	North	South
2002-2003	6 Jan–13 Jan	Surface	0.4	2.6	0.1	0.6
		Bottom	0.4	3.4		
2003-2004	29 Dec–12 Jan	Surface	0.2	3.0	2.0	2.3
		Bottom	0.1	3.5		

<sup>a</sup> Bottom water salinities were not measured during 1982-1983, 1983-1984, 1985-1986 or 1987-1988 and were estimated from the ratio of weekly mean salinities observed during 1988-1989, 1989-1990 and 1990-1991 using the following equation: Estimated bottom salinity (ppt) = observed surface s

**Table 3-16. Number of Atlantic Tomcod Caught (C) Marked and Released (M), and Recaptured (R) in the Box Trap Point Impingement, and other Sampling Efforts for Estimates of Adult Population Size, Winters of 1974-2003-2004.**

Sampling Effort	Atlantic Tomcod Winter Spawning Stock Survey <sup>a</sup>									
	1974-1975	1975-1976	1976-1977	1977-1978	1978-1979	1979-1980	1980-1981	1981-1982	1982-1983	1983-1984
North Box Traps (RM $\geq$ 47; km75) Number Marked (M) <sup>b</sup>	14,786	38,202	55,881	6,501	8,174	15,378	2,264	9,314	17,552	23,781
South Box Traps (RM<47; km75) Catch (C)	2,108	4,909	8,571	5,922	17,103	11,626	511	3,971	16,391	8,351
Recaptures (R)	4	21	11	0	4	19	0	1	2	5
R/C	0.0019	0.0043	0.0013	0.0	0.0002	0.0016	0.0	0.0	0.00012	0.0006
Percent of Total Catch	29	54	53	59	60	70	24	74	52	5
Indian Point Impingement <sup>c</sup> Catch (C)	4,385	3,700	6,140	4,409	10,497	4,784	1,483	1,240	998	25
Recaptures (R)	23	71	26	26	31	5	0	0	0	0
R/C	0.0052	0.0192	0.0042	0.0059	0.0030	0.0010	0.0	0.0	0.0	0.0038
Percent of Total Catch	61	41	38	44	36	29	71	23	3	0.0038
Other <sup>d</sup> Catch (C)	696	465	1,445	223	825	209	101	170	14,053	6,651
Recaptures (R)	1	1	9	0	4	3	0	0	18	1
R/C	0.0014	0.0022	0.0062	0.0	0.0048	0.0144	0.0	0.0	0.00128	0.0028
Percent of Total Catch	10	5	9	2	3	2	5	3	45	4
Total Catch (C)	7,189	9,054	16,156	10,108	28,841	16,619	2,095	5,381	31,442	15,261
Recaptures (R)	28	93	46	26	39	27	0	1	20	2
R/C	0.0039	0.0103	0.0028	0.0026	0.0014	0.0016	0	0.00019	0.00064	0.0019

Table 3-16. (Continued)

Sampling Effort	Atlantic Tomcod Winter Spawning Stock Survey <sup>a</sup>									
	1988-1989	1989-1990	1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998
North Box Traps (RM $\geq$ 47;km75) Number Marked (M) <sup>b</sup>	39,315	24,339	19,235	3,802	21,291	6,934	6,240	1,703	5,944	12,59
South Box Traps (RM<47;km75) Catch (C)	5,980	4,117	2,312	693	2,611	1,575	2,494	203	1,851	4
Recaptures (R)	5	4	9	1	16	0	1	0	0	0
R/C	0.00084	0.00097	0.00389	0.00144	0.00613	0.00000	0.00040	0.00000	0.00000	0.0022
Percent of Total Catch	18	14	24	25	19	47	31	53	34	1
Indian Point Impingement <sup>c</sup> Catch (C)										
Recaptures (R)										
R/C										
Percent of Total Catch										
Other <sup>d</sup> Catch (C)	27,962	24,833	7,295	2,107	11,398	1,759	5,433	180	3,609	2,41
Recaptures (R)	99	29	24	17	50	12	6	1	0	1
R/C	0.00354	0.00117	0.00329	0.00807	0.00439	0.00682	0.00110	0.00556	0.00000	0.0062
Percent of Total Catch	82	86	76	75	81	53	69	47	66	8
Total Catch (C)	33,942	28,950	9,607	2,800	14,009	3,334	7,927	383	5,460	2,87
Recaptures (R)	104	33	33	18	66	12	7	1	0	1
R/C	0.00306	0.00114	0.00343	0.00643	0.00471	0.00360	0.00088	0.00261	0.00000	0.0055

**Table 3-16. (Continued)**

Sampling Effort	Atlantic Tomcod Winter Spawning Stock Survey <sup>a</sup>			
	2000-2001	2001-2002	2002-2003	2003-2004
North Box Traps (RM $\geq$ 47;km75) Number Marked (M) <sup>b</sup>	6,758	139	373	5,034
South Box Traps (RM<47;km75) Catch (C)	4,289	265	762	5,600
Recaptures (R)	6	1	1	2
R/C	0.00140	0.00377	0.00131	0.00036
Percent of Total Catch	50	67	86	62
Indian Point Impingement <sup>c</sup> Catch (C)				
Recaptures (R)				
R/C				
Percent of Total Catch				
Other <sup>d</sup> Catch (C)	4,236	130	122	3,479
Recaptures (R)	9	0	0	6
R/C	0.00212	0.00000	0.00000	0.00172
Percent of Total Catch	50	33	14	38
Total Catch (C)	8,525	395	884	9,079
Recaptures (R)	15	1	1	8
R/C	0.00176	0.00253	0.00113	0.00088

<sup>a</sup> Survey was not conducted during the 1984-1985 and 1986-1987 spawning seasons.

<sup>b</sup> Number marked and released was adjusted for handling mortality of 10% prior to 1 January and 2.5% on and after 1 January of each year.

<sup>c</sup> Impingement collections were not examined for finclipped Atlantic tomcod from 1987-1988 to present.

<sup>d</sup> Includes Bowline and Lovett impingement collections (1976-1977 through 1981-1982); bottom trawls, beach seines, and try trawl below RM 47; km 75 (1974-1975 through 1976-1977); 9 m and 12 m trawl data (1982-1983 and 1983-1984); 9 m and 12 m trawl data (1985-1986 and 1987-1988), and 9 m trawl data 1988-1989 to present. Number of trawls and fish marked and released in North box traps for consistency among years.

**Table 3-17. Petersen Estimates of the Hudson River Atlantic Tomcod Spawning Population, Winters of 1974-1975 through 2003-2004.**

Spawning Survey	Atlantic Tomcod Petersen Population Estimate (Millions of Fish)		
	Reported Estimate <sup>a</sup>	Adjusted Estimate <sup>d</sup>	Trawl Estimate <sup>f</sup>
1974-1975	3.8	2.7	
1975-1976	3.7	2.0	
1976-1977	10.4 <sup>b</sup>	12.7	
1977-1978	2.5	1.1	
1978-1979	6.0	2.7	
1979-1980	9.1	5.4 <sup>c</sup>	
1980-1981	-- <sup>c</sup>		
1981-1982	-- <sup>c</sup>		
1982-1983			12.5
1983-1984			6.7
1984-1985			NS <sup>g</sup>
1985-1986			2.1
1986-1987			NS <sup>g</sup>
1987-1988			3.5
1988-1989			5.9
1989-1990			6.8
1990-1991			3.2
1991-1992			0.4
1992-1993			2.6
1993-1994			0.7
1994-1995			2.4
1995-1996			0.09
1996-1997			3.3
1997-1998			1.3
1998-1999			0.6
1999-2000			0.2
2000-2001			2.5
2001-2002			0.04
2002-2003			0.1
2003-2004			1.7

<sup>a</sup> TI (1981)

<sup>b</sup> Adjusted Schaefer estimate

<sup>c</sup> Insufficient number of recaptured fish (<2)

<sup>d</sup> Adjusted estimate = impingement recapture estimate from Table 3-22 in NAI (1992)

<sup>e</sup> Adjusted estimate = reported estimate/1.7

<sup>f</sup> Trawl estimate from Appendix Table E-8

<sup>g</sup> No survey

**APPENDIX A**  
**Gear Characteristics**

**Appendix Table A-1. Specifications of the Box Traps Used in the Atlantic Tomcod Survey.**

Frame	3 x 3 x 6 ft (0.9 x 0.9 x 1.8 m)
Number of wings	None
Number of leads	None
Number of fykes	2
Fyke opening	4 x 4 in. (10 x 10 cm)
Body mesh	3/8 in. (1 cm)

**Appendix Table A-2. Specifications of the 9 m Trawl.**

Head rope length	6.9 m
Foot rope length (Sweep)	9.0 m
Legs	6.0 m
Net body length	5.2 m
Cod end section	2.3 m
Doors (steel V-doors)	1.0 m
Mesh – body	7.6 cm (stretch) mesh, knotless polypropylene
– cod end	3.8 cm (stretch) mesh, knotless polypropylene
Roller Gear	25.4 cm rollers spaced with 5 cm cookie disks

## **APPENDIX B**

### **Water Quality**

## 2003-2004 Tomcod Report

**Appendix Table B-1. Weekly and Regional Average Water Temperature and Conductivity during Box Trap Sampling for Atlantic Tomcod in the Hudson River, 2003-2004.**

Hudson River Region	Week (Beginning Monday)	Surface Water Temperature (°C)	Surface Water Conductivity (μS/cm)	Bottom Water Temperature (°C)	Bottom Water Conductivity (μS/cm)
Tappan Zee	1-Dec-2003	4.9	3031	4.8	3104
	8-Dec-2003	5.1	7350	5.1	7812
	15-Dec-2003	3.2	2235	3.2	2281
	22-Dec-2003	1.3	506	1.3	521
	29-Dec-2003	2.3	283	2.3	290
	5-Jan-2004	2.3	3717	2.3	3817
	12-Jan-2004	0.3	5345	0.2	5398
	19-Jan-2004	0.3	5134	0.0	5293
	26-Jan-2004	0.0	2563	0.1	2543
	2-Feb-2004	0.5	5344	0.4	5367
	9-Feb-2004	1.1	8985	0.9	9171
	16-Feb-2004	1.5	12166	1.4	12329
	23-Feb-2004	2.3	8208	2.1	8269
Croton-Haverstraw	1-Dec-2003	3.5	387	3.5	387
	8-Dec-2003	5.0	4695	5.0	4714
	15-Dec-2003	2.5	301	2.4	326
	22-Dec-2003	1.5	254	1.5	254
	29-Dec-2003	2.0	250	2.0	250
	5-Jan-2004	2.2	1486	2.2	1509
	12-Jan-2004	0.5	990	0.5	990
	19-Jan-2004	0.2	1092	0.4	1098
	26-Jan-2004	0.0	943	0.0	957
	2-Feb-2004	0.6	3178	0.6	3389
	9-Feb-2004	1.0	6296	0.8	6416
	16-Feb-2004	1.8	4857	1.7	4935
	23-Feb-2004	2.5	4319	2.5	4355
Indian Point	1-Dec-2003	4.5	298	4.5	298
	8-Dec-2003	5.1	1816	4.9	1853
	15-Dec-2003	1.9	247	1.9	250
	22-Dec-2003	2.5	228	2.5	228
	29-Dec-2003	2.3	229	2.3	229
	5-Jan-2004	2.4	770	2.7	942
	12-Jan-2004	0.6	385	0.6	386
	19-Jan-2004	0.7	364	0.5	360
	26-Jan-2004	0.0	346	0.0	348
	2-Feb-2004	0.7	3493	0.6	3979
	9-Feb-2004	1.5	3799	1.3	3843
	16-Feb-2004	1.7	3006	1.7	3042
	23-Feb-2004	2.5	2007	2.4	2045

(continued)

## 2003-2004 Tomcod Report

Appendix Table B-1. (Continued)

Hudson River Region	Week (Beginning Monday)	Surface Water Temperature (°C)	Surface Water Conductivity (μS/cm)	Bottom Water Temperature (°C)	Bottom Water Conductivity (μS/cm)
West Point	1-Dec-2003	5.2	198	5.5	197
	8-Dec-2003	4.1	214	4.0	213
	15-Dec-2003	1.2	231	1.0	214
	22-Dec-2003	1.5	284	1.3	229
	29-Dec-2003	1.7	210	1.7	212
	5-Jan-2004	2.0	200	2.0	199
	12-Jan-2004	0.4	212	0.2	216
	19-Jan-2004	0.8	231	0.2	233
	26-Jan-2004	0.0	255	0.0	255
	2-Feb-2004	0.5	1656	0.3	1799
	9-Feb-2004	0.7	1225	0.7	1241
	16-Feb-2004	0.5	496	0.5	509
	23-Feb-2004	1.1	312	1.1	309
Cornwall	1-Dec-2003	5.0	197	5.0	198
	8-Dec-2003	3.9	215	3.6	212
	15-Dec-2003	1.0	228	1.2	228
	29-Dec-2003	4.5	344	3.0	248
	5-Jan-2004	2.3	220	2.3	223
	12-Jan-2004	0.5	238	0.5	245
	19-Jan-2004	0.2	256	0.2	255
	26-Jan-2004	0.0	338	0.0	275
	2-Feb-2004	0.4	332	0.4	332
	9-Feb-2004	0.6	435	0.6	451
	16-Feb-2004	0.3	272	0.2	276
	23-Feb-2004	1.4	275	1.5	270
Poughkeepsie	1-Dec-2003	5.0	202	5.0	204
	8-Dec-2003	2.9	188	2.6	189
	15-Dec-2003	0.6	211	0.8	209
	29-Dec-2003	2.3	210	2.3	212
	5-Jan-2004	2.0	186	2.0	186
	12-Jan-2004	0.0	228	0.0	230
	19-Jan-2004	0.4	254	0.3	255
	26-Jan-2004	0.0	257	0.0	258
	2-Feb-2004	0.3	265	0.3	270
	9-Feb-2004	0.6	223	0.6	222
	16-Feb-2004	1.0	235	0.5	234

(continued)

## 2003-2004 Tomcod Report

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Appendix Table B-1. (Continued)

Hudson River Region	Week (Beginning Monday)	Surface Water Temperature (°C)	Surface Water Conductivity (μS/cm)	Bottom Water Temperature (°C)	Bottom Water Conductivity (μS/cm)
All	1-Dec-2003	4.7	1049	4.8	1070
	8-Dec-2003	4.4	2484	4.2	2584
	15-Dec-2003	1.9	777	1.9	800
	22-Dec-2003	1.6	344	1.5	339
	29-Dec-2003	2.2	238	2.0	232
	5-Jan-2004	2.2	1313	2.2	1374
	12-Jan-2004	0.4	1199	0.3	1211
	19-Jan-2004	0.4	1247	0.2	1275
	26-Jan-2004	0.0	818	0.0	830
	2-Feb-2004	0.5	2359	0.4	2520
	9-Feb-2004	0.8	2786	0.8	2835
	16-Feb-2004	1.1	4424	1.0	4486
	23-Feb-2004	1.8	3325	1.8	3407

## 2003-2004 Tomcod Report

**Appendix Table B-2. Weekly and Regional Average Water Temperature and Conductivity during Trawl Sampling for Atlantic Tomcod in the Hudson River, 2003-2004.**

Region	Week	Surface Water Temperature (°C)	Surface Water Conductivity (μS/cm)	Bottom Water Temperature (°C)	Bottom Water Conductivity (μS/cm)
Upper Harbor	3-Nov-2003	14.0	21718	14.5	36811
	10-Nov-2003	12.3	19944	13.5	39058
	24-Nov-2003	10.0	21166	11.0	33707
	1-Dec-2003	7.3	19775	9.0	33539
	8-Dec-2003	5.8	26048	6.9	36606
	15-Dec-2003	4.3	12670	6.3	36975
	29-Dec-2003	3.0	8049	5.5	30230
	5-Jan-2004	4.1	21320	5.9	37233
	12-Jan-2004	3.0	24400	4.1	38795
	19-Jan-2004	1.0	37364	1.5	41306
	9-Feb-2004	1.6	33176	1.7	40133
	16-Feb-2004	2.0	39003	2.5	41705
	23-Feb-2004	2.4	29015	2.9	33808
	1-Mar-2004	4.0	26665	4.0	34817
	8-Mar-2004	4.5	13748	4.5	24007
	15-Mar-2004	5.0	10335	4.5	26088
	22-Mar-2004	5.0	22208	4.5	33146
5-Apr-2004	6.5	22096	6.0	31689	
Battery	3-Nov-2003	13.5	8951	14.1	26282
	10-Nov-2003	11.5	14010	13.1	31984
	17-Nov-2003	9.8	10879	11.6	29288
	24-Nov-2003	10.3	15909	10.9	25321
	1-Dec-2003	6.9	6257	9.2	23096
	8-Dec-2003	5.7	18102	6.6	29644
	15-Dec-2003	3.8	8001	5.7	27315
	22-Dec-2003	3.6	13610	4.8	23520
	29-Dec-2003	2.4	4675	5.6	31117
	5-Jan-2004	3.2	15304	5.6	32789
	12-Jan-2004	1.0	15686	3.2	30231
	19-Jan-2004	0.2	25529	1.2	33655
	2-Feb-2004	0.7	23945	1.0	34647
	9-Feb-2004	1.1	21483	1.2	30825
	16-Feb-2004	1.7	27053	2.0	34580
	23-Feb-2004	2.4	19434	2.3	29269
	1-Mar-2004	4.3	14777	3.6	34414
	8-Mar-2004	4.6	16194	4.5	27125
	15-Mar-2004	4.0	14360	4.2	29815
	22-Mar-2004	4.9	14360	4.2	30260
29-Mar-2004	6.6	6732	5.3	30989	
5-Apr-2004	6.5	14885	6.0	26735	
12-Apr-2004	7.7	11060	6.8	28480	

**Appendix Table B-3. Weekly Mean Bottom Water Salinity for Box Trap Stations during the 2003-2004 Atlantic T**

Week	Tappan Zee		Croton-Haverstraw	Indian Point		West Point		Cornwall		
	25 <sup>a</sup>	29	36	41	43	51	52	56		
	East <sup>a</sup>	West	East	East	East	West	East	West	West	
1-Dec-2003	2.2796	0.1951	0.2170	0.2092	0.1244	0.1127	.	0.1093	0.1110	0
8-Dec-2003	5.1066	3.2661	2.6767	1.4709	0.7273	0.1342	.	0.1137	0.1187	0
15-Dec-2003	1.4156	0.9337	0.1827	0.1383	0.1423	0.1163	.	0.1221	0.1280	0
22-Dec-2003	0.2790	0.3311	0.1424	0.1239	0.1317	0.1289	.	0.1278	.	
29-Dec-2003	0.1626	.	0.1402	0.1267	0.1301	0.1181	0.1230	0.1148	0.1390	0
5-Jan-2004	2.3965	1.6960	0.8488	0.6908	0.2075	0.1093	0.1132	0.1119	0.1247	0
12-Jan-2004	3.4977	1.3843	0.5562	0.2876	0.1455	0.1160	0.1284	0.1169	0.1371	0
19-Jan-2004	3.3299	2.7977	0.6172	0.3035	0.1511	0.1305	.	0.1303	0.1431	0
26-Jan-2004	.	1.4349	0.5374	.	0.1952	0.1435	.	0.1424	0.1542	0
2-Feb-2004	.	3.0559	1.9188	3.6798	1.9022	0.8541	1.2864	0.7176	0.1859	0
9-Feb-2004	5.3357	5.1977	3.6612	2.6105	1.7456	0.7370	0.6383	0.7370	0.2528	0
16-Feb-2004	7.9552	4.8090	2.8037	2.1876	1.2539	0.2557	0.3310	0.2557	0.1548	0
23-Feb-2004	5.0211	3.9221	2.4701	1.6538	0.6539	0.1761	0.1688	0.1761	0.1512	
<b>All</b>	<b>3.9795</b>	<b>2.7830</b>	<b>1.6538</b>	<b>1.2801</b>	<b>0.7737</b>	<b>0.2586</b>	<b>0.4145</b>	<b>0.2506</b>	<b>0.1588</b>	<b>0</b>

<sup>a</sup> Stations labeled by river mile and site (east or west shore); may include more than one trap.

## **APPENDIX C**

### **Atlantic Tomcod Catch Characteristics**

**2003-2004 Tomcod Report**

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**Appendix Table C-1. Number of Samples, Atlantic Tomcod Caught, and Atlantic Tomcod Marked in the Hudson River Cross-Classified by Use Code and Region for the 9 m Trawl and Box Traps, Winter 2003-2004.**

<b>Region</b>	<b>Gear</b>	<b>Use Code</b>	<b>Number of Samples</b>	<b>Number of Atlantic Tomcod Caught</b>	<b>Number of Atlantic Tomcod Marked</b>
Upper Harbor	9 m trawl	1	59	179	0
		2	5	0	0
		5	2	0	0
Battery	9 m trawl	1	835	4774	0
		2	3	10	0
		5	3	0	0
Tappan Zee	Box trap	1	98	5429	4961
		2	2	75	75
		5	3	0	0
Croton-Haverstraw	Box trap	1	65	86	77
Indian Point	Box trap	1	60	10	7
		5	1	0	0
West Point	Box trap	1	140	3477	3184
		2	2	306	305
		5	4	0	0
Cornwall	Box trap	1	57	1358	1240
		5	1	0	0
Poughkeepsie	Box trap	1	36	616	611
		5	5	0	0

## 2003-2004 Tomcod Report

**Appendix Table C-2. Box Trap Catch per Hour of Atlantic Tomcod in the Hudson River, Winter 2003-2004.**

Sampling Week (beginning Monday)		Hudson River Regions						All Regions Combined
		TZ	CH	IP	WP	CW	PK	
1-Dec-2003	C/H	0.01	0.00	0.00	0.00	0.00	0.00	<0.01
	Duration	258.4	94.1	93.6	122.2	35.1	17.4	620.7
8-Dec-2003	C/H	0.02	0.01	0.00	0.00	0.00	0.00	0.01
	Duration	513.4	338.0	310.9	504.6	337.6	262.1	2266.7
15-Dec-2003	C/H	0.39	0.05	<0.01	0.05	0.00	0.00	0.11
	Duration	565.3	329.4	307.4	502.3	286.1	428.4	2418.9
22-Dec-2003	C/H	2.32	0.00	0.00	3.13	.	.	1.85
	Duration	283.5	152.9	154.9	337.3	.	.	928.7
29-Dec-2003	C/H	1.77	0.02	0.00	1.27	0.53	0.15	0.65
	Duration	573.4	516.2	516.6	937.1	634.0	939.5	4116.7
5-Jan-2004	C/H	1.94	0.07	0.02	1.25	1.98	1.12	1.34
	Duration	1040.2	250.8	296.3	722.6	376.0	338.8	3024.6
12-Jan-2004	C/H	2.33	0.07	0.01	0.37	0.80	0.30	0.61
	Duration	396.1	426.9	381.7	744.0	291.7	337.7	2577.9
19-Jan-2004	C/H	2.19	0.01	0.01	0.09	0.11	0.00	0.34
	Duration	172.5	310.8	166.0	213.5	426.3	42	1331.1
26-Jan-2004	C/H	0.92	0.00	0.00	0.01	<0.01	0.00	0.10
	Duration	168.9	364.6	170.0	335.9	318.4	169.9	1527.7
2-Feb-2004	C/H	0.06	0.01	0.00	0.01	0.00	0.00	0.01
	Duration	143.6	286.5	166.1	362.8	307.7	190.4	1457.0
9-Feb-2004	C/H	0.05	<0.01	0.00	<0.01	0.00	0.00	0.01
	Duration	266.0	383.8	387.9	955.0	381.0	381.8	2755.4
16-Feb-2004	C/H	0.03	<0.01	0.00	0.00	0.00	0.00	0.01
	Duration	664.6	332.4	332.4	837.3	336.5	95.9	2599.0
23-Feb-2004	C/H	0.02	0.00	0.00	<0.01	0.00	.	<0.01
	Duration	586.5	284.8	288.2	742.9	150.5	.	2052.7

**2003-2004 Tomcod Report**

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**Appendix Table C-3. Average Catch Per Ten Minute Tow for Atlantic Tomcod Caught in the 9 m Trawl in the Hudson River South of the George Washington Bridge, Winter 2003-2004.**

Week	Upper Harbor			Battery		
	Tows	CPUE	S.E.	Tows	CPUE	S.E.
3-Nov-2003	2	0.00	0.00	35	8.46	1.3
10-Nov-2003	2	0.00	0.00	45	9.84	1.52
17-Nov-2003				39	13.10	1.86
24-Nov-2003	1	3.00		26	8.88	1.17
1-Dec-2003	2	0.00	0.00	30	9.70	1.62
8-Dec-2003	6	0.00	0.00	34	10.26	1.19
15-Dec-2003	7	2.00	0.82	33	5.70	1.27
22-Dec-2003				25	4.64	0.77
29-Dec-2003	1	0.00		34	0.88	0.15
5-Jan-2004	11	0.00	0.00	27	0.48	0.15
12-Jan-2004	2	0.00	0.00	20	4.25	1.13
19-Jan-2004	2	8.00	8.00	17	14.76	5.04
2-Feb-2004				15	11.00	1.37
9-Feb-2004	9	6.56	5.13	39	8.38	1.98
16-Feb-2004	2	0.00	0.00	34	5.50	0.78
23-Feb-2004	7	8.00	3.74	48	5.77	1.44
1-Mar-2004	1	0.00		57	2.65	0.54
8-Mar-2004				47	2.17	0.34
15-Mar-2004				42	1.88	0.49
22-Mar-2004	2	4.00	4.00	48	3.35	0.56
29-Mar-2004				48	4.33	0.50
5-Apr-2004	2	11.50	1.50	41	4.24	0.67
12-Apr-2004				51	2.73	0.37
<b>Total CPUE</b>	<b>59</b>	<b>3.03</b>	<b>1.00</b>	<b>835</b>	<b>5.72</b>	<b>0.27</b>

**Appendix Table C-4. Weekly Report of Atlantic Tomcod Caught in the Hudson River in a 9 m Trawl and in Box Trawls during the Spawning Period, Winter 2003-2004.**

Sampling Week	Gear	Water		N Tows		Number of Atlantic Tomcod Caught by Size Group (mm TL)									Fish per Tow	Number of		
		Temp	Cond.	Valid	Void	<126	126-150	151-175	176-200	201-225	226-250	251-275	276+	Total		Released	Recaptured	Released
3 Nov 2003	9m	14.2	26851	37	0	2	64	172	56	0	0	2	0	296	8.0	180	0	1
10 Nov 2003	9m	13.1	32285	47	0	1	42	232	157	11	0	0	0	443	9.4	330	1	1
17 Nov 2003	9m	11.6	29288	39	0	2	39	263	177	29	1	0	0	511	13.1	401	9	1
24 Nov 2003	9m	10.9	25920	27	1	1	13	104	103	10	1	1	1	234	8.7	126	7	1
1 Dec 2003	9m	9.2	23748	32	0	0	22	98	141	28	2	0	0	291	9.1	175	8	1
8 Dec 2003	9m	6.7	30833	41	0	0	14	93	189	44	6	1	2	349	8.5	243	5	1
15 Dec 2003	9m	5.9	29200	41	0	0	10	49	119	22	1	0	1	202	4.9	97	5	1
22 Dec 2003	9m	4.8	23520	25	0	0	4	21	66	22	3	0	0	116	4.6	9	5	1
29 Dec 2003	9m	5.6	31092	35	0	0	0	8	16	5	0	1	0	30	0.9	5	0	
5 Jan 2004	9m	5.7	34156	39	0	0	1	4	3	4	0	1	0	13	0.3	6	1	
12 Jan 2004	9m	3.3	31601	25	0	0	1	8	42	40	2	1	1	95	3.8	0	1	
19 Jan 2004	9m	1.2	34420	20	1	0	2	47	124	66	9	7	12	267	13.4	116	0	1
2 Feb 2004	9m	1.0	34647	16	0	0	7	54	73	31	0	0	0	165	10.3	106	2	
9 Feb 2004	9m	1.3	32571	48	1	0	11	112	164	85	5	5	4	386	8.0	267	5	1
16 Feb 2004	9m	2.0	34965	36	1	0	13	55	74	36	7	1	1	187	5.2	70	2	1
23 Feb 2004	9m	2.4	29846	55	0	1	23	98	124	77	6	2	2	333	6.1	228	5	1
1 Mar 2004	9m	3.7	34421	58	1	0	1	15	68	55	9	1	2	151	2.6	48	2	1
8 Mar 2004	9m	4.5	27059	47	0	0	3	18	47	31	3	0	0	102	2.2	9	2	
15 Mar 2004	9m	4.2	29726	42	0	0	1	8	35	29	5	1	0	79	1.9	25	2	
22 Mar 2004	9m	4.2	30375	50	0	0	0	10	60	76	15	4	4	169	3.4	92	4	
29 Mar 2004	9m	5.3	30989	48	0	0	0	3	53	117	19	2	14	208	4.3	102	2	1
5 Apr 2004	9m	6.0	26966	43	0	0	0	16	76	79	20	1	5	197	4.6	91	1	1
12 Apr 2004	9m	6.8	28480	51	0	0	0	16	53	60	8	0	2	139	2.7	51	1	
<b>Trawl Totals</b>		<b>5.8</b>	<b>30129</b>	<b>902</b>	<b>5</b>	<b>7</b>	<b>271</b>	<b>1504</b>	<b>2020</b>	<b>957</b>	<b>122</b>	<b>31</b>	<b>51</b>	<b>4963</b>	<b>5.5</b>	<b>2777</b>	<b>70</b>	<b>2</b>

Appendix Table C-4. (Continued)

Sampling Week	Gear	Region	Water		Number of Atlantic Tomcod Caught by Size Group (mm TL)									Number of Fish			
			Temp.	Cond.	<126	126-150	151-175	176-200	201-225	226-250	251-275	276+	Total	Released	Recaptured	Label	
1 Dec03	Bx	N	5.3	199	0	0	0	0	0	0	0	0	0	0	0	0	0
1 Dec03	Bx	S	4.4	1723	0	0	0	2	0	0	0	0	2	2	0	0	0
8 Dec03	Bx	N	3.5	205	0	1	1	0	0	0	0	0	2	2	0	0	0
8 Dec03	Bx	S	5.0	5071	0	0	10	4	1	0	1	0	16	13	0	3	0
15 Dec03	Bx	N	1.0	216	0	1	12	8	2	0	0	2	25	24	0	1	0
15 Dec03	Bx	S	2.6	1253	0	28	134	58	11	4	1	2	238	225	2	11	0
22 Dec03	Bx	N	1.3	229	1	111	548	317	46	14	10	9	1056	933	6	117	0
22 Dec03	Bx	S	1.6	381	1	96	355	164	37	6	0	0	659	659	0	0	0
29 Dec03	Bx	N	1.9	214	0	113	808	591	241	56	37	48	1894	1817	18	58	0
29 Dec03	Bx	S	2.2	265	0	118	435	314	132	21	2	3	1025	913	9	103	0
5 Jan04	Bx	N	2.1	203	2	150	898	679	273	61	15	17	2095	1941	42	112	0
5 Jan04	Bx	S	2.4	2780	4	242	869	619	268	27	6	5	2040	1787	22	174	0
12 Jan04	Bx	N	0.2	225	1	67	302	189	37	6	4	3	609	559	21	29	0
12 Jan04	Bx	S	0.4	2500	1	105	450	337	60	6	2	1	962	902	11	49	0
19 Jan04	Bx	N	0.2	247	0	7	37	22	1	0	0	0	67	58	4	5	0
19 Jan04	Bx	S	0.3	2541	1	60	265	108	15	0	2	0	451	433	7	0	0
26 Jan04	Bx	N	0.0	261	0	0	1	2	0	0	0	0	3	3	0	0	0
26 Jan04	Bx	S	0.1	1526	0	20	93	32	7	0	3	0	155	148	7	0	0
2 Feb04	Bx	N	0.3	1171	0	1	2	0	0	0	0	0	3	2	0	1	0
2 Feb04	Bx	S	0.6	4028	0	2	5	3	0	1	0	0	11	6	1	4	0
9 Feb04	Bx	N	0.6	839	0	1	1	0	0	0	0	0	2	0	0	2	0
9 Feb04	Bx	S	1.0	6618	0	5	7	1	0	0	0	0	13	12	0	1	0
16 Feb04	Bx	N	0.4	434	0	0	0	0	0	0	0	0	0	0	0	0	0
16 Feb04	Bx	S	1.5	8159	0	4	7	7	1	0	0	0	19	13	2	4	0
23 Feb04	Bx	N	1.2	302	0	0	0	0	1	0	0	0	1	1	0	0	0
23 Feb04	Bx	S	2.3	5735	0	1	5	2	0	0	0	1	9	7	0	2	0
<b>Totals</b>	<b>Bx</b>	<b>N</b>	<b>1.4</b>	<b>365</b>	<b>4</b>	<b>452</b>	<b>2610</b>	<b>1808</b>	<b>601</b>	<b>137</b>	<b>66</b>	<b>79</b>	<b>5757</b>	<b>5340</b>	<b>91</b>	<b>325</b>	<b>0</b>
	<b>Bx</b>	<b>S</b>	<b>1.9</b>	<b>3275</b>	<b>7</b>	<b>681</b>	<b>2635</b>	<b>1651</b>	<b>532</b>	<b>65</b>	<b>17</b>	<b>12</b>	<b>5600</b>	<b>5120</b>	<b>61</b>	<b>351</b>	<b>0</b>
	<b>Bx</b>	<b>All</b>	<b>1.6</b>	<b>1820</b>	<b>11</b>	<b>1133</b>	<b>5245</b>	<b>3459</b>	<b>1133</b>	<b>202</b>	<b>83</b>	<b>91</b>	<b>11357</b>	<b>10460</b>	<b>152</b>	<b>676</b>	<b>0</b>

**Appendix Table C-4. (Continued)**

SAMPLING WEEK	=	Date of Monday beginning each week
GEAR	=	9 m trawl (9m) or box traps (Bx)
REGION	=	North box trap region (N) or south box trap region (S)
WATER:		
TEMP.	=	Mean river bottom water temperature in °C
COND.	=	Mean river bottom conductivity in microSiemens/cm at 25°
N TOWS:		
VALID	=	Total number of valid tows (USE_CODES 1 and 2 combined) by the specified gear in the specified week
VOID	=	Total number of void tows (USE_CODE = 5) by the specified gear in the specified week
FISH PER TOW	=	Number of fish caught per valid tow (trawl)
NUMBER OF FISH:		
RELEASED	=	Number of Atlantic tomcod marked and released
RECAPTURED	=	Number of Atlantic tomcod recaptured from the current program
LAB	=	Number of fish taken to the laboratory for biocharacteristics and/or fecundity analyses
OLD RECAPTURE	=	Number of Atlantic tomcod recaptured from previous years' programs
MORTALITY:		
N	=	Number of dead fish in samples
%	=	Percent of dead fish in samples

Appendix Table C-5. Length Frequencies of Atlantic Tomcod by Gear and Week in the Hudson River, Winter 200

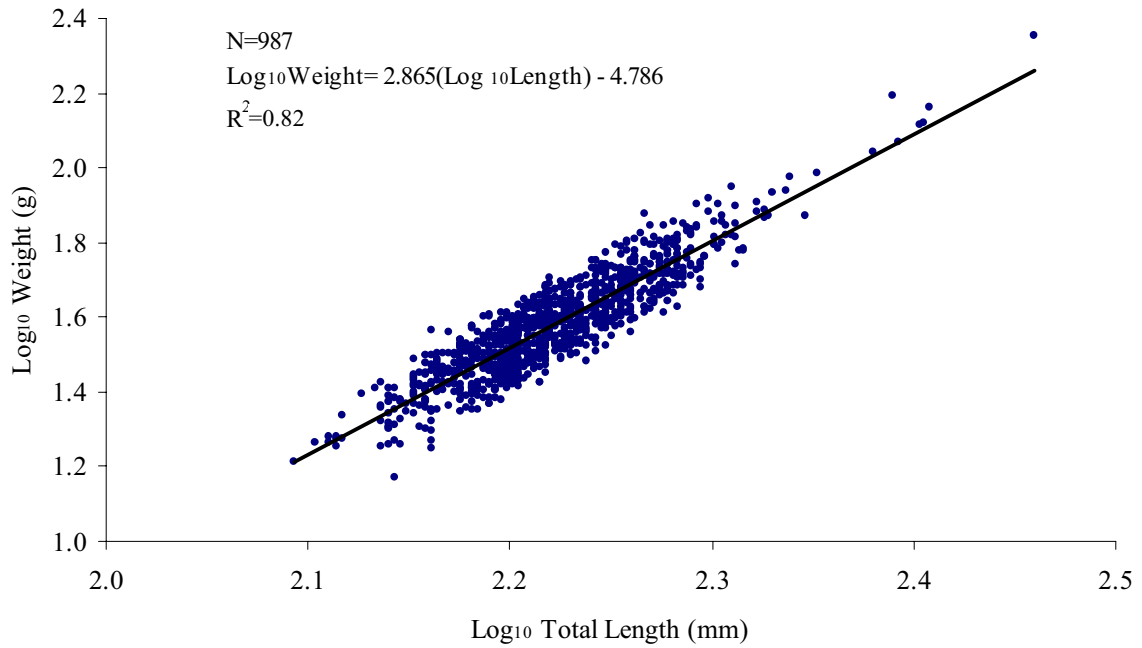
Gear	Sampling Week (Beginning Mon)	Number of Samples	Length Group 1	Length Group 2	Length Group 3	Length Group 4	Length Group 5	Length Group 6
Box traps	1 Dec 2003	14				2		
	8 Dec 2003	43		1	11	4	1	
	15 Dec 2003	56		29	146	66	13	4
	22 Dec 2003	12	2	207	903	481	83	20
	29 Dec 2003	24		231	1243	905	373	77
	5 Jan 2004	34	6	392	1767	1298	541	88
	12 Jan 2004	29	2	172	752	526	97	12
	19 Jan 2004	24	1	67	302	130	16	
	26 Jan 2004	20		20	94	34	7	
	2 Feb 2004	34		3	7	3		1
	9 Feb 2004	54		6	8	1		
	16 Feb 2004	60		4	7	7	1	
	23 Feb 2004	56		1	5	2	1	
	<b>Total</b>	460	11	1133	5245	3459	1133	202
Trawls	3 Nov 2003	37	2	64	172	56		
	10 Nov 2003	47	1	42	232	157	11	
	17 Nov 2003	39	2	39	263	177	29	1
	24 Nov 2003	27	1	13	104	103	10	1
	1 Dec 2003	32		22	98	141	28	2
	8 Dec 2003	41		14	93	189	44	6
	15 Dec 2003	41		10	49	119	22	1
	22 Dec 2003	25		4	21	66	22	3
	29 Dec 2003	35			8	16	5	
	5 Jan 2004	39		1	4	3	4	
	12 Jan 2004	25		1	8	42	40	2
	19 Jan 2004	20		2	47	124	66	9
	2 Feb 2004	16		7	54	73	31	
	9 Feb 2004	48		11	112	164	85	5
	16 Feb 2004	36		13	55	74	36	7
	23 Feb 2004	55	1	23	98	124	77	6
	1 Mar 2004	58		1	15	68	55	9
	8 Mar 2004	47		3	18	47	31	3

**Appendix Table C-5. (Continued)**

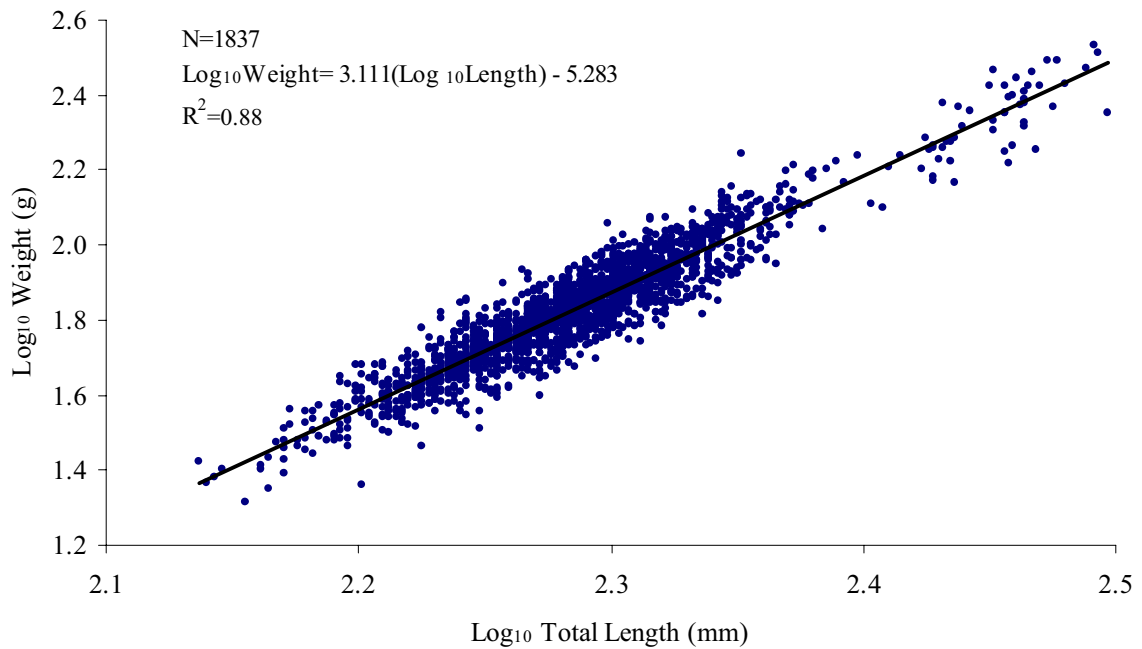
<b>Gear</b>	<b>Sampling Week (Beginning Mon)</b>	<b>Number of Samples</b>	<b>Length Group 1</b>	<b>Length Group 2</b>	<b>Length Group 3</b>	<b>Length Group 4</b>	<b>Length Group 5</b>	<b>Length Group 6</b>
Trawls (cont'd)	15 Mar 2004	42		1	8	35	29	5
	22 Mar 2004	50			10	60	76	15
	29 Mar 2004	48			3	53	117	19
	5 Apr 2004	43			16	76	79	20
	12 Apr 2004	51			16	53	60	8
	<b>Total</b>	902	7	271	1504	2020	957	122
<b>All Gears</b>		<b>1362</b>	<b>18</b>	<b>1404</b>	<b>6749</b>	<b>5479</b>	<b>2090</b>	<b>324</b>

## **Appendix D**

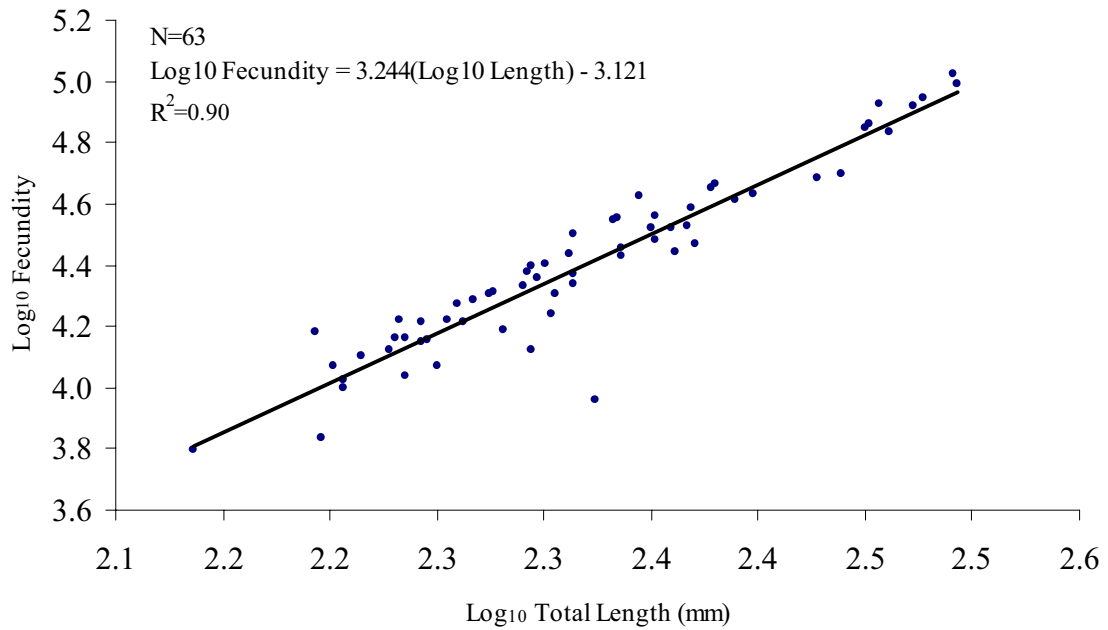
### **Atlantic Tomcod Biocharacteristics**



Appendix Figure D-1. Length-weight regression for male Atlantic tomcod collected in the Hudson River during the spawning season, winter 2003-2004.



Appendix Figure D-2. Length-weight regression for female Atlantic tomcod collected in the Hudson River during the spawning season, winter 2003-2004.



Appendix Figure D-3. Relationship between fecundity and length for female Atlantic tomcod collected in the Hudson River during the spawning season, winter 2003-2004.

**Appendix Table D-1. Sex Ratio and Proportion of Males in Weekly Samples of Atlantic Tomcod in the Hudson River, Winter 2003-2004.**

Gear	Sampling Week (Beginning Mon)	Laboratory Samples						Male
		Males	Females	Total	Ratio (Males/ Females)	Proportion Males	Proportion Females	
<b>Box Traps</b>	1-Dec-2003	0	0	0	.	.	.	
	8-Dec-2003	1	2	3	0.500	0.333	0.667	6
	15-Dec-2003	9	3	12	3.000	0.750	0.250	197
	22-Dec-2003	101	16	117	6.313	0.863	0.137	1480
	29-Dec-2003	97	67	164	1.448	0.591	0.409	1726
	5-Jan-2004	191	103	294	1.854	0.650	0.350	2686
	12-Jan-2004	63	18	81	3.500	0.778	0.222	1221
	19-Jan-2004	5	3	8	1.667	0.625	0.375	323
	26-Jan-2004	0	0	0	.	.	.	
	2-Feb-2004	4	1	5	4.000	0.800	0.200	11
	9-Feb-2004	3	0	3	.	1.000	0.000	15
	16-Feb-2004	4	0	4	.	1.000	0.000	19
	23-Feb-2004	2	0	2	.	1.000	0.000	10
	<b>Total</b>		<b>480</b>	<b>213</b>	<b>693</b>			
<b>Trawls</b>	3-Nov-2003	53	63	116	0.841	0.457	0.543	135
	10-Nov-2003	44	68	112	0.647	0.393	0.607	174
	17-Nov-2003	26	56	82	0.464	0.317	0.683	162
	24-Nov-2003	22	25	47	0.880	0.468	0.532	109
	1-Dec-2003	25	67	92	0.373	0.272	0.728	79
	8-Dec-2003	5	20	25	0.250	0.200	0.800	69
	15-Dec-2003	29	66	95	0.439	0.305	0.695	61
	22-Dec-2003	8	67	75	0.119	0.107	0.893	12
	29-Dec-2003	0	25	25	0.000	0.000	1.000	0
	5-Jan-2004	1	5	6	0.200	0.167	0.833	2
	12-Jan-2004	1	92	93	0.011	0.011	0.989	1
	19-Jan-2004	6	145	151	0.041	0.040	0.960	10
	2-Feb-2004	21	37	58	0.568	0.362	0.638	59
	9-Feb-2004	18	97	115	0.186	0.157	0.843	60

Appendix Table D-1. (Continued)

Gear	Sampling Week (Beginning Mon)	Laboratory Samples						Male
		Males	Females	Total	Ratio (Males/ Females)	Proportion Males	Proportion Females	
Trawls (cont'd)	16-Feb-2004	38	78	116	0.487	0.328	0.672	61
	23-Feb-2004	59	42	101	1.405	0.584	0.416	194
	1-Mar-2004	10	80	90	0.125	0.111	0.889	16
	8-Mar-2004	21	66	87	0.318	0.241	0.759	24
	15-Mar-2004	4	46	50	0.087	0.080	0.920	6
	22-Mar-2004	14	55	69	0.255	0.203	0.797	34
	29-Mar-2004	2	102	104	0.020	0.019	0.981	4
	5-Apr-2004	10	84	94	0.119	0.106	0.894	20
	12-Apr-2004	19	68	87	0.279	0.218	0.782	30
	<b>Total</b>	<b>436</b>	<b>1454</b>	<b>1890</b>				<b>1330</b>
<b>All Gears</b>	<b>Total</b>	<b>916</b>	<b>1667</b>	<b>2583</b>			<b>9028</b>	

**Appendix Table D-2. Sexual Condition of Male and Female Atlantic Tomcod in Box Trap Biocharacteristics Sampling Stations in the Hudson River during the Spawning Season, Winter 2003-2004.**

Sampling Week (Beginning Monday)		Male							Female					
		Ripe	Ripe and Running	Partially Spent	Spent	Resting	Developing	Mature	Total	Ripe	Ripe and Running	Partially Spent	Spent	Resting
Age 1	8-Dec-2003	1							1	2				
	15-Dec-2003	7							7	2				
	22-Dec-2003	1	98						99	7				
	29-Dec-2003	14	72	10	1				97	47	1	4	9	
	5-Jan-2004		23	115	50	1			189	14	48	27	14	
	12-Jan-2004	1	11	36	15				63	7	2		9	
	19-Jan-2004			3	2				5			2	1	
	2-Feb-2004			4					4				1	
	9-Feb-2004			1	2				3					
	16-Feb-2004		1	2	1				4					
	23-Feb-2004		2						2					
	<b>Total</b>	<b>24</b>	<b>207</b>	<b>171</b>	<b>71</b>	<b>1</b>		<b>474</b>	<b>79</b>	<b>51</b>	<b>33</b>	<b>34</b>		
Age 2	15-Dec-2003	2							2	1				
	22-Dec-2003		2						2	8				1
	29-Dec-2003									2		3	1	
	5-Jan-2004		1	1					2					
		<b>Total</b>	<b>2</b>	<b>3</b>	<b>1</b>				<b>6</b>	<b>11</b>		<b>3</b>	<b>1</b>	<b>1</b>

**Appendix Table D-3. Sexual Condition by Station of Male and Female Atlantic Tomcod in Box Trap Biocharacter Collected in the Hudson River during the Spawning Season, Winter 2003-2004.**

Station	Age	Week	Male						Female			
			Ripe	Ripe and Running	Partially Spent	Spent	Resting	Total	Ripe	Ripe and Running	Partially Spent	S
Cornwall	Age 1	5 Jan 2004		4	33	20		57		4	5	
		12 Jan 2004			5			5				
		19 Jan 2004			1	2		3			1	
	Total	0	4	39	22	0	65	0	4	6		
	Age 2	5 Jan 2004			1			1				
		Total	0	1	0	0	0	1	0	0	0	
<b>Grand Total</b>			<b>0</b>	<b>5</b>	<b>39</b>	<b>22</b>	<b>0</b>	<b>66</b>	<b>0</b>	<b>4</b>	<b>6</b>	
West Point	Age 1	15 Dec 2003	1					1				
		22 Dec 2003	1	98				99	7			
		29 Dec 2003	4	24	6	1		35	6	1	3	
		5 Jan 2004		3	6	4		13		4	1	
		12 Jan 2004		3	4	1		8	1	2		
		19 Jan 2004			2			2			1	
		2 Feb 2004			1			1				
		9 Feb 2004			1	1		2				
	Total	6	128	20	7	0	161	14	7	5	1	
	Age 2	22 Dec 2003			2			2	8			
		29 Dec 2003						0	1		2	
		Total	0	2	0	0	0	2	9	0	2	
		<b>Grand Total</b>			<b>6</b>	<b>130</b>	<b>20</b>	<b>7</b>	<b>0</b>	<b>163</b>	<b>23</b>	<b>7</b>
Garrison	Age 1	5 Jan 2004			11	2		13	1	5	3	
		12 Jan 2004		2	4	4		10	2			
		Total	0	2	15	6	0	23	3	5	3	
	Age 2	5 Jan 2004			1			1				
		Total	0	0	1	0	0	1		0	0	
<b>Grand Total</b>			<b>0</b>	<b>2</b>	<b>16</b>	<b>6</b>	<b>0</b>	<b>24</b>	<b>3</b>	<b>5</b>	<b>3</b>	
Indian Point	Age 1	8 Dec 2003						0	1			
		5 Jan 2004			1			1				
		Total	0	0	1	0	0	1	1	0	0	
	<b>Grand Total</b>			<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>1</b>	<b>0</b>	<b>0</b>

Appendix Table D-3. (Continued)

Station	Age	Week	Male						Female				
			Ripe	Ripe and Running	Partially Spent	Spent	Resting	Total	Ripe	Ripe and Running	Partially Spent	S	
Croton	Age 1	8 Dec 2003						0	1				
		15 Dec 2003						0	1				
		5 Jan 2004		1	1			2	3	2			
		Total	0	1	1	0	0	2	5	2	0		
		<b>Grand Total</b>	<b>0</b>	<b>1</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>2</b>	<b>5</b>	<b>2</b>	<b>0</b>		
Nyack	Age 1	2 Feb 2004			3			3					
		9 Feb 2004				1		1					
		Total	0	0	3	1	0	4	0	0	0		
		<b>Grand Total</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>4</b>	<b>0</b>	<b>0</b>	<b>0</b>		
Irvington	Age 1	8 Dec 2003	1					1					
		15 Dec 2003	6					6	1				
		29 Dec 2003	10	48	4			62	41		1		
		5 Jan 2004		15	63	24	1	103	10	33	18		
		12 Jan 2004	1	6	23	10		40	4				
		16 Feb 2004		1	2	1		4					
		23 Feb 2004		2				2					
		Total	18	72	92	35	1	218	56	33	19	1	
	Age 2	15 Dec 2003	2					2	1				
		29 Dec 2003						0	1		1		
			Total	2	0	0	0	0	2	2	0	1	
			<b>Grand Total</b>	<b>20</b>	<b>72</b>	<b>92</b>	<b>35</b>	<b>1</b>	<b>220</b>	<b>58</b>	<b>33</b>	<b>20</b>	<b>1</b>

**Appendix Table D-4. Sexual Condition of Male and Female Atlantic Tomcod in Trawl Biocharacteristics Samples Hudson River during the Spawning Season, Winter 2003-2004.**

Sampling Week (beginning Monday)		Male							Female					
		Ripe	Ripe and Running	Partially Spent	Spent	Resting	Developing	Mature	Total	Ripe	Ripe and Running	Partially Spent	Spent	Resting
<b>Age 1</b>	3-Nov-2003						53		53					
	10-Nov-2003						44		44					1
	17-Nov-2003	2					24		26					
	24-Nov-2003	7					15		22	4				
	1-Dec-2003	4					21		25	24				
	8-Dec-2003						5		5					
	15-Dec-2003	8					21		29	46				1
	22-Dec-2003	3					5		8	61				
	29-Dec-2003									24				
	5-Jan-2004									3				
	12-Jan-2004				1				1				90	
	19-Jan-2004			1	5				6		1	1	135	
	2-Feb-2004				19	2			21				22	15
	9-Feb-2004				16	2			18				87	6
	16-Feb-2004			1	23	14			38		1		72	4
	23-Feb-2004			2	42	14			58				42	
	1-Mar-2004				4	6			10			1	43	34
	8-Mar-2004				6	15			21				64	2
	15-Mar-2004					4			4				13	32
	22-Mar-2004					13			13	1			11	42
29-Mar-2004					2			2				1	91	
5-Apr-2004					10			10					82	
12-Apr-2004					19			19					67	
<b>Total</b>	<b>24</b>		<b>4</b>	<b>116</b>	<b>101</b>		<b>188</b>		<b>433</b>	<b>163</b>	<b>2</b>	<b>2</b>	<b>580</b>	<b>377</b>

Appendix Table D-4. (Continued)

Sampling Week (beginning Monday)		Male							Female					
		Ripe	Ripe and Running	Partially Spent	Spent	Resting	Developing	Mature	Total	Ripe	Ripe and Running	Partially Spent	Spent	Resting
Age 2	24-Nov-2003									1				
	29-Dec-2003												1	
	5-Jan-2004		1						1				2	
	12-Jan-2004												2	
	19-Jan-2004												8	
	9-Feb-2004												4	
	16-Feb-2004												1	
	23-Feb-2004			1					1					
	1-Mar-2004												1	1
	22-Mar-2004					1			1					1
	29-Mar-2004												4	6
	5-Apr-2004												1	1
	12-Apr-2004													1
	<b>Total</b>		<b>1</b>	<b>1</b>	<b>1</b>				<b>3</b>	<b>1</b>			<b>24</b>	<b>10</b>

**Appendix Table D-5. Analysis of Variance Results from Least Squares Regression on 2003-2004 Atlantic Tomcod**

Appendix Figure Number	Model		Analysis of Variance						
	Dependent Variable	Independent Variable	Source	df	SS	MS	F	P > F	R-Square
D-1 (male)	Log <sub>10</sub> Weight	Log <sub>10</sub> Length	Model	1	15.84	15.84	4,579.4	<0.0001	0.82
			Error	985	3.41	0.003			
			<b>Total</b>	<b>986</b>	<b>19.25</b>				
D-2 (female)	Log <sub>10</sub> Weight	Log <sub>10</sub> Length	Model	1	44.70	44.70	13,416.0	<0.0001	0.88
			Error	1,835	6.11	0.003			
			<b>Total</b>	<b>1,836</b>	<b>50.81</b>				
D-3 (female)	Log <sub>10</sub> Fecundity	Log <sub>10</sub> Length	Model	1	4.62	4.62	536.0	<0.0001	0.90
			Error	61	0.53	0.009			
			<b>Total</b>	<b>62</b>	<b>5.15</b>				

Df = degrees of freedom

SS = sum of squares

MS = mean square

F = calculated F-ratio

p&gt;F = probability of obtaining a larger F-ratio

S.E. = standard error

## 2003-2004 Tomcod Report

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**Appendix Table D-6. Predicted Weight for Pre- and Postspawning Male and Female Atlantic Tomcod Caught by 9 m Trawls or Box Traps in the Hudson River, Winter 2003-2004.**

Sex	Reproductive Stage	Gear	Predicted Weight (Grams) at Length <sup>a</sup>		
			N	125 mm	175 mm
Male	Prespawning	9 m trawl	36	17.8	51.7
		Box trap	26	16.6	46.5
	Postspawning	Box trap	69	14.2	37.7
		9 m trawl	114	14.8	40.3
Female	Prespawning	9 m trawl	201	18.6	56.0
		Box trap	90	19.5	56.2
	Postspawning	Box trap	32	11.9	38.8
		9 m trawl	619	16.5	46.1

<sup>a</sup> Back-transformed from  $\text{Log}_{10}$  weight, which was predicted using the following regression equation:  
 $\text{Log}_{10} \text{ weight} = b_0 + b_1 (\text{Log}_{10} \text{ length})$ .

## **APPENDIX E**

### **Atlantic Tomcod Distribution and Movements**

**2003-2004 Tomcod Report**

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**Appendix Table E-1. Atlantic Tomcod Marked with Visual Implant Tags in Box Traps between Yonkers and Poughkeepsie and Recaptured in a 9 m Trawl South of the George Washington Bridge in the Hudson River, Winter 2003-2004.**

Tag Number	Release		Recapture		Days at Large	Distance Moved		Sex	Total Length (mm)	Age
	Date	River Mile	Date	River Mile		Miles	Km			
OPF	8 Jan 04	56	9 Feb 04	8	32	48	77	M	159	1
XUU	14 Jan 04	56	9 Feb 04	-2	26	58	93	M	164	1
OGP	31 Dec 03	51	12 Feb 04	9	43	42	68	M	169	1
YKO	16 Jan 04	29	9 Feb 04	8	24	21	34	M	179	1
TWA	7 Jan 04	25	5 Feb 04	8	29	17	27	M	168	1
TWB	7 Jan 04	25	27 Feb 04	9	51	16	26	M	168	1
WWZ	12 Jan 04	25	18 Feb 04	8	37	17	27	M	167	1
WXL	12 Jan 04	25	9 Mar 04	8	57	17	27	M	195	1
OAK	30 Dec 03	52	26 Mar 04	8	87	44	71	F	211	1
RRO	5 Jan 04	52	6 Feb 04	8	32	44	71	F	193	1
TUK	6 Jan 04	51	1 Apr 04	7	86	44	71	F	212	1
NFM	30 Dec 03	25	9 Jan 04	9	10	16	26	F	219	1
SRW	6 Jan 04	25	12 Feb 04	1	37	24	39	F	194	1

**Appendix Table E-2. Recaptured Atlantic Tomcod Cross-Classified by Release and Recapture Period for Fish Marked From Box Traps North of the Bear Mountain Bridge and Recaptured in a 9 m Trawl South of the Washington Bridge in the Hudson River, Winter 2003-2004.**

Recapture Period	Number Examined for Tags (C)	Statistic	Recaptured Atlantic Tomcod from Release Week(s) Beginning								
			1 Dec-8 Dec M = 2	15 Dec M = 22	22 Dec M = 840	29 Dec M = 1,671	5 Jan M = 1,892	12 Jan M = 545	19 Jan M = 57	26 Jan M = 3	2 Feb M = 2
1-8 Dec	640	R R/M R/C	0 0.00000 0.00000								
15 Dec	202	R R/M R/C	0 0.00000 0.00000	0 0.00000 0.00000							
22 Dec	116	R R/M R/C	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000						
29 Dec	30	R R/M R/C	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000					
5 Jan	13	R R/M R/C	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000				
12 Jan	95	R R/M R/C	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000			
19 Jan	267	R R/M R/C	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000		
26 Jan	0	R R/M R/C	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000	
2 Feb	165	R R/M R/C	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000	1 0.00053 0.00606	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000
9 Feb	386	R R/M R/C	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000	2 0.00120 0.00518	0 0.00000 0.00000	1 0.00183 0.00259	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000

Appendix Table E-2. (Continued)

Recapture Period	Number Examined for Tags (C)	Statistic	Recaptured Atlantic Tomcod from Release Week(s) Beginning									
			1 Dec-8 Dec M = 2	15 Dec M = 22	22 Dec M = 840	29 Dec M = 1,671	5 Jan M = 1,892	12 Jan M = 545	19 Jan M = 57	26 Jan M = 3	2 Feb M = 2	
16 Feb	187	R	0	0	0	0	0	0	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
23 Feb	333	R	0	0	0	0	0	0	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1 Mar	151	R	0	0	0	0	0	0	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
8 Mar	102	R	0	0	0	0	0	0	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
15 Mar	79	R	0	0	0	0	0	0	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
22 Mar	169	R	0	0	0	1	0	0	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00060	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00592	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
29 Mar	208	R	0	0	0	0	1	0	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00053	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00481	0.00000	0.00000	0.00000	0.00000	0.00000
5 Apr	197	R	0	0	0	0	0	0	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
12 Apr	139	R	0	0	0	0	0	0	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
<b>Total</b>	<b>3,479</b>	<b>R</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
		<b>R/M</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00180</b>	<b>0.00106</b>	<b>0.00183</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00000</b>
		<b>R/C</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00086</b>	<b>0.00057</b>	<b>0.00029</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00000</b>

M = Number of fish tagged and released from box traps north of the Bear Mountain Bridge, adjusted for handling mortality of 10.0% prior to 1 January.

C = Number of fish caught and examined for tags from a 9 m trawl in the Battery region.

R = Number of Atlantic Tomcod tagged and released from box traps north of the Bear Mountain Bridge and recaptured from a 9 m trawl in the Battery region.

R/M = Recapture rate.

R/C = Recapture proportion.

**Appendix Table E-3. Recaptured Atlantic Tomcod Cross-Classified by Release and Recapture Period for Fish Marked from Box Traps in the Yonkers-Indian Point Region and Recaptured in a 9 m Trawl South of Washington Bridge in the Hudson River, Winter 2003-2004.**

Recapture Period	Number Examined for Tags (C)	Statistic	Recaptured Atlantic Tomcod from Release Week(s) Beginning									
			1 Dec-8 Dec M = 14	15 Dec M = 203	22 Dec M = 593	29 Dec M = 823	5 Jan M = 1,742	12 Jan M = 879	19 Jan M = 422	26 Jan M = 144	2 Feb M = 6	
1-8 Dec	640	R	0									
		R/M	0.00000									
		R/C	0.00000									
15 Dec	202	R	0	0								
		R/M	0.00000	0.00000								
		R/C	0.00000	0.00000								
22 Dec	116	R	0	0	0							
		R/M	0.00000	0.00000	0.00000							
		R/C	0.00000	0.00000	0.00000							
29 Dec	30	R	0	0	0	0						
		R/M	0.00000	0.00000	0.00000	0.00000						
		R/C	0.00000	0.00000	0.00000	0.00000						
5 Jan	13	R	0	0	0	1	0					
		R/M	0.00000	0.00000	0.00000	0.00122	0.00000					
		R/C	0.00000	0.00000	0.00000	0.07692	0.00000					
12 Jan	95	R	0	0	0	0	0	0	0			
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000		
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000		
19 Jan	267	R	0	0	0	0	0	0	0	0		
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
26 Jan	0	R	0	0	0	0	0	0	0	0	0	
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C										
2 Feb	165	R	0	0	0	0	1	0	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00057	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00606	0.00000	0.00000	0.00000	0.00000	0.00000
9 Feb	386	R	0	0	0	0	1	1	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00057	0.00114	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00259	0.00259	0.00000	0.00000	0.00000	0.00000

Appendix Table E-3. (Continued)

Recapture Period	Number Examined for Tags (C)	Statistic	Recaptured Atlantic Tomcod from Release Week(s) Beginning								
			1 Dec– 8 Dec M = 14	15 Dec M = 203	22 Dec M = 593	29 Dec M = 823	5 Jan M = 1,742	12 Jan M = 879	19 Jan M = 422	26 Jan M = 144	2 Feb M = 6
16 Feb	187	R	0	0	0	0	0	1	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00114	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00535	0.00000	0.00000	0.00000
23 Feb	333	R	0	0	0	0	1	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00057	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00300	0.00000	0.00000	0.00000	0.00000
1 Mar	151	R	0	0	0	0	0	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
8 Mar	102	R	0	0	0	0	0	1	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00114	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00980	0.00000	0.00000	0.00000
15 Mar	79	R	0	0	0	0	0	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
22 Mar	169	R	0	0	0	0	0	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
29 Mar	208	R	0	0	0	0	0	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5 Apr	197	R	0	0	0	0	0	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
12 Apr	139	R	0	0	0	0	0	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
<b>Total</b>	<b>3,479</b>	<b>R</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>3</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>0</b>
		<b>R/M</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00122</b>	<b>0.00172</b>	<b>0.00341</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00000</b>
		<b>R/C</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00029</b>	<b>0.00086</b>	<b>0.00086</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00000</b>

M = number of fish tagged and released from box traps south of the Bear Mountain Bridge, adjusted for handling mortality of 10.0% prior to 1 January.

C = number of fish caught and examined for tags from a 9 m trawl in the Battery region.

R = number of Atlantic tomcod tagged and released from box traps south of the Bear Mountain Bridge and recaptured from a 9 m trawl in the Battery.

R/M = Recapture rate.

R/C = Recapture proportion.



Appendix Table E-4. (Continued)

Recapture Period	Number Examined for Tags (C)	Statistic	Recaptured Atlantic Tomcod from Release Week(s) Beginning								
			1 Dec–8 Dec M = 14	15 Dec M = 203	22 Dec M = 593	29 Dec M = 823	5 Jan M = 1,742	12 Jan M = 879	19 Jan M = 422	26 Jan M = 144	2 Feb M = 6
16 Feb	19	R	0	0	0	0	0	1	1	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00114	0.00237	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.05263	0.05263	0.00000	0.00000
23 Feb	9	R	0	0	0	0	0	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
<b>Total</b>	<b>5,600</b>	<b>R</b>	<b>0</b>	<b>5</b>	<b>3</b>	<b>14</b>	<b>18</b>	<b>6</b>	<b>6</b>	<b>2</b>	<b>0</b>
		<b>R/M</b>	<b>0.00000</b>	<b>0.02469</b>	<b>0.00506</b>	<b>0.01702</b>	<b>0.01033</b>	<b>0.00682</b>	<b>0.01421</b>	<b>0.01386</b>	<b>0.00000</b>
		<b>R/C</b>	<b>0.00000</b>	<b>0.00089</b>	<b>0.00054</b>	<b>0.00250</b>	<b>0.00321</b>	<b>0.00107</b>	<b>0.00107</b>	<b>0.00036</b>	<b>0.00000</b>

M = number of fish tagged and released from box traps south of the Bear Mountain Bridge, adjusted for handling mortality of 10.0% prior to 1 January.

C = number of fish caught and examined for tags in box traps south of the Bear Mountain Bridge.

R = number of Atlantic tomcod tagged, released, and recaptured from box traps south of the Bear Mountain Bridge.

R/M = Recapture rate.

R/C = Recapture proportion.



Appendix Table E-5. (Continued)

Recapture Period	Number Examined for Tags (C)	Statistic	Recaptured Atlantic Tomcod from Release Week(s) Beginning								
			1 Dec– 8 Dec M = 2	15 Dec M = 22	22 Dec M = 840	29 Dec M = 1,671	5 Jan M = 1,892	12 Jan M = 545	19 Jan M = 57	26 Jan M = 3	2 Feb M = 2
16 Feb	0	R R/M R/C	0 0.00000	0 0.00000	0 0.00000	0 0.00000	0 0.00000	0 0.00000	0 0.00000	0 0.00000	0 0.00000
23 Feb	1	R R/M R/C	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000	0 0.00000 0.00000
<b>Total</b>	<b>5,757</b>	<b>R</b> <b>R/M</b> <b>R/C</b>	<b>0</b> <b>0.00000</b> <b>0.00000</b>	<b>1</b> <b>0.04630</b> <b>0.00017</b>	<b>17</b> <b>0.02025</b> <b>0.00295</b>	<b>37</b> <b>0.02214</b> <b>0.00643</b>	<b>22</b> <b>0.01163</b> <b>0.00382</b>	<b>2</b> <b>0.00367</b> <b>0.00035</b>	<b>3</b> <b>0.05305</b> <b>0.00052</b>	<b>0</b> <b>0.00000</b> <b>0.00000</b>	<b>0</b> <b>0.00000</b> <b>0.00000</b>

M = number of fish tagged and released from box traps north of the Bear Mountain Bridge, adjusted for handling mortality of 10.0% prior to 1 January.

C = number of fish caught and examined for tags in box traps north of the Bear Mountain Bridge.

R = number of Atlantic tomcod tagged, released, and recaptured from box traps north of the Bear Mountain Bridge.

R/M = recapture rate.

R/C = recapture proportion.



Appendix Table E-6. (Continued)

Recapture Period	Number Examined for Tags (C)	Statistic	Recaptured Atlantic Tomcod from Release Week(s) Beginning									
			1 Dec– 8 Dec M = 2	15 Dec M = 22	22 Dec M = 840	29 Dec M = 1,671	5 Jan M = 1,892	12 Jan M = 545	19 Jan M = 57	26 Jan M = 3	2 Feb M = 2	
16 Feb	19	R	0	0	0	0	0	0	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
23 Feb	9	R	0	0	0	0	0	0	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
<b>Total</b>	<b>5,600</b>	<b>R</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
		<b>R/M</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00119</b>	<b>0.00000</b>	<b>0.00053</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00000</b>
		<b>R/C</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00018</b>	<b>0.00000</b>	<b>0.00018</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00000</b>	<b>0.00000</b>

M = number of fish tagged and released from box traps north of the Bear Mountain Bridge, adjusted for handling mortality of 10.0% prior to 1 January January.

C = number of fish caught and examined for tags in box traps south of the Bear Mountain Bridge.

R = number of Atlantic tomcod tagged and released from box traps north of the Bear Mountain Bridge and recaptured in box traps south of the Bear Mountain Bridge.

R/M = recapture rate.

R/C = recapture proportion.

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**Appendix Table E-7. Atlantic Tomcod Marked and Released during Winter 2002-2003 and Recaptured during Winter 2003-2004 in the Hudson River.**

Tag Number	Recapture				Release				Sex	Total Length (mm)	Age
	Date	Gear	Mile	Km	Date	Gear	Mile	Km			
DAV	31 Dec 2003	Box trap	56	90	26 Dec 2002	Box trap	36	58	Male	217	2

**Appendix Table E-8. Mean 9 m Trawl Catch per Ten Minute Tow during the Trawl Recapture Period as an Index Estimate of Atlantic Tomcod Population Size in the Hudson River, Winters of 1982-1983 through 2000-2001**

Box Trap Marking Period <sup>a</sup>	Trawl Recapture Period	Petersen Trap-Trawl Estimate								9 m Trawl Catch	
		Mark/Recapture Statistics <sup>b</sup>					Population Estimate (Millions with 95% Confidence Limits) <sup>c</sup>			No. Tows	Mean (G)
		M	C	R	R/M	R/C	Lower	Estimate	Upper		
29 Nov 1982–26 Feb 1983	2 Jan–18 Mar 1983	17,552	14,053	18	0.00103	0.00128	8.1	12.5	20.3	157	
28 Nov 1983–6 Mar 1984	2 Jan–25 Mar 1984	25,004	6,655	24	0.00096	0.00361	4.6	6.7	10.2	242	
2 Dec 1985–3 Jan 1986	30 Dec 1985–21 Mar 1986	13,953	21,755	144	0.01032	0.00662	1.8	2.1	2.5	619	
14 Dec 1987–29 Jan 1988	4 Jan–22 Apr 1988	12,458	10,473	36	0.00289	0.00344	2.6	3.5	5.0	624	
12 Dec 1988–29 Jan 1989	9 Jan–15 Apr 1989	43,589	16,776	123	0.00282	0.00733	5.0	5.9	7.0	730	
11 Dec 1989–28 Jan 1990	26 Feb–13 Apr 1990	26,227	7,523	28	0.00107	0.00372	4.8	6.8	10.1	334	
17 Dec 1990–27 Jan 1991	21 Jan–19 Apr 1991	20,006	4,169	25	0.00125	0.00600	2.2	3.2	4.9	587	
23 Dec 1991–23 Feb 1992	20 Jan–26 Apr 1992	4,186	1,856	19	0.00454	0.01024	0.2	0.4	0.6	642	
7 Dec 1992–7 Feb 1993	11 Jan–18 Apr 1993	23,100	6,853	61	0.00264	0.00890	2.0	2.6	3.3	478	
13 Dec 1993–30 Jan 1994	7 Feb–17 Apr 1994	7,661	1,471	16	0.00209	0.01088	0.4	0.7	1.1	353	
12 Dec 1994–12 Feb 1995	13 Feb–19 Mar 1995	8,367	3,418	11	0.00131	0.00322	1.4	2.4	4.5	165	
11 Dec 1995–19 Feb 1996	26 Feb–15 Apr 1996	1,862	94	1	0.00054	0.01064	0.03	0.09	0.16	376	
23 Dec 1996–2 Feb 1997	27 Jan–30 Mar 1997	5,743	1,711	2	0.00035	0.00117	1.0	3.3	6.1	396	
22 Dec 1997–15 Feb 1998	12 Jan–19 Apr 1998	11,738	1,870	16	0.00136	0.00856	0.8	1.3	2.2	575	
28 Dec 1998–21 Feb 1999	1 Feb–11 Apr 1999	3,834	772	4	0.00104	0.00518	0.3	0.6	1.5	304	
27 Dec 1999–30 Jan 2000	14 Feb–9 Apr 2000	1,475	981	7	0.00475	0.00714	0.1	0.2	0.4	344	
11 Dec 2000–11 Feb 2001	15 Jan–8 Apr 2001	10,240	3,667	14	0.00137	0.00382	1.5	2.5	4.3	433	

**Table E-8. (Continued)**

Petersen Trap-Trawl Estimate										9 m Trawl C		
Box Trap Marking Period <sup>a</sup>	Trawl Recapture Period	Mark/Recapture Statistics <sup>b</sup>							Population Estimate (Millions with 95% Confidence Limits) <sup>c</sup>		No. Tows	Me (G
		M	C	R	R/M	R/C	Lower	Estimate	Upper			
31 Dec 1901–17 Feb 2002	4 Feb–21 Apr 2002	326	124	0	0.00000	0.00000	0.009	0.04	— <sup>d</sup>	374		
23 Dec 02–23 Feb 2003	3 Feb–20 Apr 2003	951	113	0	0.00000	0.00000	0.02	0.1	— <sup>d</sup>	345		
15 Dec 2003–1 Feb 2004	5 Jan–11 Apr 2004	9,836	2,352	13	0.00132	0.00553	1.0	1.7	2.9	481		

<sup>a</sup>The winter survey was not conducted during 1984-1985 and 1986-1987.

<sup>b</sup>R = number of marked Atlantic tomcod released from box traps and recaptured by trawls.

M = number of fish marked and released in box traps, adjusted for handling mortality of 10% prior to 1 January and 2.5% on and after 1 January.

C = number of fish caught and examined for marks.

<sup>c</sup>Preferred estimate.

<sup>d</sup>A meaningful upper confidence limit could not be calculated because there were fewer than two recaptures.

## **APPENDIX F**

### **Atlantic Tomcod Tagging Program**

**Appendix Table F-1. Release and Recapture Statistics for Atlantic Tomcod Marked with Visual Implant Tags in B  
Yonkers and Poughkeepsie or in Trawls South of the George Washington Bridge and Recapt  
or a 9 m Trawl in the Hudson River, Winter 2003-2004.**

Tag Number	Release				Recapture				Distance Moved (miles)	Da L
	Station	Date	River Mile	Length (mm)	Station	Date	River Mile	Length (mm)		
OKJ	Marlboro	31-Dec-2003	68	196	Marlboro	7-Jan-2004	68	198	0	
OLC	Marlboro	31-Dec-2003	68	164	Marlboro	7-Jan-2004	68	165	0	
OMR	Marlboro	31-Dec-2003	68	196	Cornwall	5-Jan-2004	56	200	12	
OOM	Cornwall	31-Dec-2003	56	190	Cornwall	13-Jan-2004	56	190	0	
OPF	Cornwall	31-Dec-2003	56	161	Cornwall	8-Jan-2004	56	160	0	
OPG	Cornwall	31-Dec-2003	56	174	Cornwall	5-Jan-2004	56	179	0	
ORB	Cornwall	31-Dec-2003	56	194	Cornwall	8-Jan-2004	56	185	0	
ORR	Cornwall	31-Dec-2003	56	192	Cornwall	8-Jan-2004	56	190	0	
OTK	Cornwall	31-Dec-2003	56	166	Cornwall	13-Jan-2004	56	168	0	
OTX	Cornwall	31-Dec-2003	56	173	Cornwall	5-Jan-2004	56	168	0	
OUZ	Cornwall	31-Dec-2003	56	172	Cornwall	8-Jan-2004	56	170	0	
OVI	Cornwall	31-Dec-2003	56	146	Cornwall	13-Jan-2004	56	148	0	
OWT	Cornwall	31-Dec-2003	56	153	Cornwall	13-Jan-2004	56	154	0	
PAB	Cornwall	31-Dec-2003	56	170	Cornwall	8-Jan-2004	56	173	0	
PBR	Cornwall	31-Dec-2003	56	272	Cornwall	5-Jan-2004	56	273	0	
LHN	Cornwall	5-Jan-2004	56	198	Cornwall	13-Jan-2004	56	203	0	
RKI	Cornwall	5-Jan-2004	56	190	Cornwall	13-Jan-2004	56	188	0	
RVY	Cornwall	5-Jan-2004	56	240	Cornwall	8-Jan-2004	56	238	0	
RWC	Cornwall	5-Jan-2004	56	176	West Point-N	14-Jan-2004	52	172	4	
RXP	Cornwall	5-Jan-2004	56	177	Cornwall	8-Jan-2004	56	177	0	
RZT	Cornwall	5-Jan-2004	56	225	Cornwall	8-Jan-2004	56	221	0	
SAG	Cornwall	5-Jan-2004	56	144	Cornwall	13-Jan-2004	56	146	0	
SAU	Cornwall	5-Jan-2004	56	197	Cornwall	8-Jan-2004	56	195	0	
SCR	Cornwall	5-Jan-2004	56	166	Cornwall	8-Jan-2004	56	166	0	
SDD	Cornwall	5-Jan-2004	56	156	Cornwall	13-Jan-2004	56	155	0	
SDK	Cornwall	5-Jan-2004	56	211	Cornwall	8-Jan-2004	56	213	0	
SEA	Cornwall	5-Jan-2004	56	189	Cornwall	8-Jan-2004	56	188	0	
SFY	Cornwall	5-Jan-2004	56	187	Cornwall	8-Jan-2004	56	181	0	
SHD	Cornwall	5-Jan-2004	56	152	Cornwall	8-Jan-2004	56	154	0	
SHV	Cornwall	5-Jan-2004	56	173	Cornwall	8-Jan-2004	56	177	0	

Appendix Table F-1. (Continued)

Tag Number	Release				Recapture				Distance Moved (miles)	Da L
	Station	Date	River Mile	Length (mm)	Station	Date	River Mile	Length (mm)		
OPF	Cornwall	8-Jan-2004	56	161	Battery	9-Feb-2004	8	159	48	
OTK	Cornwall	13-Jan-2004	56	166	Cornwall	14-Jan-2004	56	167	0	
XNG	Cornwall	13-Jan-2004	56	150	Cornwall	21-Jan-2004	56	150	0	
XSK	Cornwall	13-Jan-2004	56	162	Cornwall	14-Jan-2004	56	160	0	
XUU	Cornwall	14-Jan-2004	56	161	Upper Harbor	9-Feb-2004	2	164	58	
YXR	Cornwall	21-Jan-2004	56	175	Cornwall	22-Jan-2004	56	173	0	
YYG	Cornwall	21-Jan-2004	56	152	Cornwall	22-Jan-2004	56	157	0	
YYN	Cornwall	21-Jan-2004	56	186	Cornwall	22-Jan-2004	56	187	0	
CDS	West Point-N	19-Dec-2003	52	149	West Point-N	24-Dec-03	52	152	0	
DKR	West Point-N	23-Dec-2003	52	143	West Point-N	2-Jan-2004	52	148	0	
DNR	West Point-N	23-Dec-2003	52	150	Cornwall	8-Jan-2004	56	149	4	
DPS	West Point-N	23-Dec-2003	52	170	West Point-N	24-Dec-03	52	168	0	
DRG	West Point-N	23-Dec-2003	52	158	West Point-S	24-Dec-03	51	156	1	
DUM	West Point-N	23-Dec-2003	52	189	West Point-N	24-Dec-03	52	188	0	
DVX	West Point-N	23-Dec-2003	52	160	West Point-N	29-Dec-03	52	163	0	
DWB	West Point-N	23-Dec-2003	52	143	West Point-N	13-Jan-2004	52	145	0	
DWY	West Point-N	23-Dec-2003	52	140	West Point-N	24-Dec-03	52	172	0	
DYM	West Point-N	23-Dec-2003	52	175	West Point-N	30-Dec-03	52	180	0	
DZC	West Point-N	23-Dec-2003	52	168	West Point-N	24-Dec-03	52	170	0	
KNW	West Point-N	24-Dec-2003	52	180	West Point-N	13-Jan-2004	52	181	0	
KRB	West Point-N	24-Dec-2003	52	194	West Point-N	9-Jan-2004	52	198	0	
KVU	West Point-N	24-Dec-2003	52	148	Marlboro	14-Jan-2004	68	148	16	
KZP	West Point-N	24-Dec-2003	52	165	Garrison	6-Jan-2004	51	177	1	
LHE	West Point-N	24-Dec-2003	52	210	Cornwall	31-Dec-03	56	212	4	
LHN	West Point-N	24-Dec-2003	52	198	Cornwall	5-Jan-2004	56	205	4	
LTC	West Point-N	29-Dec-2003	52	215	West Point-N	30-Dec-03	52	220	0	
LUD	West Point-N	29-Dec-2003	52	150	West Point-N	30-Dec-03	52	150	0	
LUR	West Point-N	29-Dec-2003	52	161	West Point-N	30-Dec-03	52	163	0	
LWF	West Point-N	29-Dec-2003	52	167	West Point-N	30-Dec-03	52	170	0	
LYJ	West Point-N	29-Dec-2003	52	145	West Point-N	30-Dec-03	52	145	0	
LYN	West Point-N	29-Dec-2003	52	164	West Point-N	2-Jan-2004	52	164	0	
LYO	West Point-N	29-Dec-2003	52	167	West Point-N	8-Jan-2004	52	167	0	
LYS	West Point-N	29-Dec-2003	52	162	West Point-N	9-Jan-2004	52	166	0	

Appendix Table F-1. (Continued)

Tag Number	Release				Recapture				Distance Moved (miles)	Da L
	Station	Date	River Mile	Length (mm)	Station	Date	River Mile	Length (mm)		
LZU	West Point-N	29-Dec-2003	52	189	West Point-N	30-Dec-03	52	192	0	
NVP	West Point-N	30-Dec-2003	52	200	West Point-N	13-Jan-2004	52	200	0	
NWK	West Point-N	30-Dec-2003	52	178	West Point-N	13-Jan-2004	52	178	0	
OAK	West Point-N	30-Dec-2003	52	202	Battery	26-Mar-2004	8	211	44	
ODS	West Point-N	30-Dec-2003	52	182	Garrison	31-Dec-03	51	182	1	
OEF	West Point-N	30-Dec-2003	52	171	Cornwall	5-Jan-2004	56	172	4	
PHY	West Point-N	2-Jan-2004	52	157	West Point-N	5-Jan-2004	52	163	0	
PSI	West Point-N	2-Jan-2004	52	168	Garrison	6-Jan-2004	51	170	1	
PTW	West Point-N	2-Jan-2004	52	174	West Point-N	5-Jan-2004	52	173	0	
RHS	West Point-N	5-Jan-2004	52	161	West Point-N	13-Jan-2004	52	160	0	
RRO	West Point-N	5-Jan-2004	52	190	Battery	6-Feb-2004	8	193	44	
RTZ	West Point-N	5-Jan-2004	52	166	West Point-N	9-Jan-2004	52	168	0	
UYF	West Point-N	8-Jan-2004	52	150	West Point-N	9-Jan-2004	52	149	0	
UYG	West Point-N	8-Jan-2004	52	180	West Point-N	13-Jan-2004	52	184	0	
UZC	West Point-N	8-Jan-2004	52	161	West Point-N	9-Jan-2004	52	162	0	
LDU	West Point-S	24-Dec-2003	51	160	Irvington	13-Jan-2004	25	170	26	
LOH	West Point-S	29-Dec-2003	51	180	West Point-N	2-Jan-2004	52	178	1	
OEP	Garrison	31-Dec-2003	51	181	Garrison	2-Jan-2004	51	183	0	
OGA	Garrison	31-Dec-2003	51	159	Garrison	2-Jan-2004	51	160	0	
OGN	Garrison	31-Dec-2003	51	182	Garrison	2-Jan-2004	51	184	0	
OGP	Garrison	31-Dec-2003	51	167	Battery	12-Feb-2004	9	169	42	
PFE	West Point-S	2-Jan-2004	51	199	West Point-N	5-Jan-2004	52	200	1	
TUK	Garrison	6-Jan-2004	51	198	Battery	1-Apr-2004	7	212	44	
LCF	Croton	16-Dec-2003	36	175	Nyack	18-Dec-03	29	175	7	
PXC	Nyack	5-Jan-2004	29	158	Nyack	20-Jan-2004	29	159	0	
PYL	Nyack	5-Jan-2004	29	158	Nyack	23-Jan-2004	29	160	0	
PZA	Nyack	5-Jan-2004	29	193	Nyack	20-Jan-2004	29	187	0	
SJW	Nyack	6-Jan-2004	29	219	Nyack	8-Jan-2004	29	221	0	
SJZ	Nyack	6-Jan-2004	29	199	Nyack	23-Jan-2004	29	200	0	
BUU	Nyack	8-Jan-2004	29	170	Nyack	16-Jan-2004	29	170	0	
YIC	Nyack	16-Jan-2004	29	170	Nyack	20-Jan-2004	29	168	0	
YJH	Nyack	16-Jan-2004	29	269	Nyack	20-Jan-2004	29	267	0	
YJS	Nyack	16-Jan-2004	29	193	Irvington	17-Feb-2004	25	191	4	

Appendix Table F-1. (Continued)

Tag Number	Release				Recapture				Distance Moved (miles)	Da L
	Station	Date	River Mile	Length (mm)	Station	Date	River Mile	Length (mm)		
YKO	Nyack	16-Jan-2004	29	183	Battery	9-Feb-2004	8	179	21	
YNH	Nyack	20-Jan-2004	29	163	Nyack	22-Jan-2004	29	166	0	
YOR	Nyack	20-Jan-2004	29	145	Nyack	27-Jan-2004	29	147	0	
AAZ	Nyack	22-Jan-2004	29	192	Irvington	17-Feb-2004	25	189	4	
ABD	Nyack	22-Jan-2004	29	162	Nyack	26-Jan-2004	29	163	0	
ABJ	Nyack	22-Jan-2004	29	143	Nyack	29-Jan-2004	29	145	0	
AFW	Nyack	23-Jan-2004	29	171	Nyack	26-Jan-2004	29	173	0	
AHF	Nyack	26-Jan-2004	29	186	Nyack	27-Jan-2004	29	190	0	
ALY	Nyack	29-Jan-2004	29	127	Nyack	2-Feb-2004	29	130	0	
CCV	Irvington	18-Dec-2003	25	188	Irvington	19-Dec-03	25	189	0	
CFY	Irvington	19-Dec-2003	25	164	Irvington	29-Dec-03	25	164	0	
CHK	Irvington	19-Dec-2003	25	183	Irvington	6-Jan-2004	25	186	0	
CHM	Irvington	19-Dec-2003	25	156	Irvington	9-Jan-2004	25	158	0	
CTO	Irvington	22-Dec-2003	25	148	Irvington	29-Dec-03	25	151	0	
CXV	Irvington	22-Dec-2003	25	170	Irvington	9-Jan-2004	25	178	0	
DAN	Irvington	22-Dec-2003	25	176	Irvington	29-Dec-03	25	183	0	
MDP	Irvington	29-Dec-2003	25	208	Irvington	12-Jan-2004	25	199	0	
MDS	Irvington	29-Dec-2003	25	157	Irvington	7-Jan-2004	25	155	0	
MFF	Irvington	29-Dec-2003	25	160	Irvington	7-Jan-2004	25	164	0	
MHZ	Irvington	29-Dec-2003	25	161	Irvington	30-Dec-03	25	165	0	
MIK	Irvington	29-Dec-2003	25	171	Irvington	30-Dec-03	25	172	0	
MJC	Irvington	29-Dec-2003	25	163	Irvington	30-Dec-03	25	169	0	
MLP	Irvington	29-Dec-2003	25	208	Nyack	26-Jan-2004	29	208	4	
MMF	Irvington	29-Dec-2003	25	188	Irvington	30-Dec-03	25	189	0	
MNO	Irvington	29-Dec-2003	25	155	Irvington	30-Dec-03	25	156	0	
MWO	Irvington	30-Dec-2003	25	161	Irvington	30-Dec-03	25	163	0	
NDT	Irvington	30-Dec-2003	25	161	Irvington	7-Jan-2004	25	163	0	
NFM	Irvington	30-Dec-2003	25	225	Battery	9-Jan-2004	9	219	16	
NFW	Irvington	30-Dec-2003	25	166	Irvington	9-Jan-2004	25	166	0	
NHT	Irvington	30-Dec-2003	25	158	Irvington	6-Jan-2004	25	162	0	
NKP	Irvington	30-Dec-2003	25	156	Irvington	7-Jan-2004	25	154	0	
SOH	Irvington	6-Jan-2004	25	194	Irvington	7-Jan-2004	25	190	0	
SRW	Irvington	6-Jan-2004	25	192	Battery	12-Feb-2004	1	194	24	

Appendix Table F-1. (Continued)

Tag Number	Release				Recapture				Distance Moved (miles)	Da L
	Station	Date	River Mile	Length (mm)	Station	Date	River Mile	Length (mm)		
SWN	Irvington	6-Jan-2004	25	146	Irvington	7-Jan-2004	25	150	0	
TDT	Irvington	6-Jan-2004	25	144	Irvington	12-Jan-2004	25	150	0	
TGL	Irvington	6-Jan-2004	25	172	Irvington	7-Jan-2004	25	171	0	
THD	Irvington	6-Jan-2004	25	149	Irvington	7-Jan-2004	25	147	0	
TMF	Irvington	6-Jan-2004	25	209	Irvington	7-Jan-2004	25	205	0	
TMJ	Irvington	6-Jan-2004	25	162	Irvington	7-Jan-2004	25	163	0	
TOJ	Irvington	6-Jan-2004	25	158	Irvington	7-Jan-2004	25	156	0	
TWA	Irvington	7-Jan-2004	25	170	Battery	5-Feb-2004	8	168	17	
TWB	Irvington	7-Jan-2004	25	164	Battery	27-Feb-2004	9	168	16	
TWM	Irvington	7-Jan-2004	25	157	Irvington	12-Jan-2004	25	152	0	
UBP	Irvington	7-Jan-2004	25	154	Irvington	7-Jan-2004	25	155	0	
UCH	Irvington	7-Jan-2004	25	161	Irvington	7-Jan-2004	25	163	0	
VZD	Irvington	9-Jan-2004	25	165	Irvington	12-Jan-2004	25	156	0	
WDV	Irvington	12-Jan-2004	25	189	Irvington	13-Jan-2004	25	191	0	
WPV	Irvington	12-Jan-2004	25	198	Irvington	13-Jan-2004	25	197	0	
WWJ	Irvington	12-Jan-2004	25	186	Nyack	16-Jan-2004	29	184	4	
WWZ	Irvington	12-Jan-2004	25	169	Battery	18-Feb-2004	8	167	17	
WXL	Irvington	12-Jan-2004	25	196	Battery	9-Mar-2004	8	195	17	
IFJ	Battery	11-Nov-2003	9	202	Battery	24-Nov-03	9	206	0	
IGM	Battery	11-Nov-2003	9	186	Battery	17-Nov-03	9	190	0	
IKN	Battery	12-Nov-2003	9	192	Battery	27-Feb-2004	9	209	0	1
IKW	Battery	12-Nov-2003	9	149	Battery	25-Nov-03	9	152	0	
ITL	Battery	17-Nov-2003	9	180	Battery	12-Jan-2004	8	188	1	
IXV	Battery	18-Nov-2003	9	184	Battery	21-Nov-03	9	184	0	
JEU	Battery	21-Nov-2003	9	196	Battery	26-Nov-03	9	199	0	
JFE	Battery	21-Nov-2003	9	164	Irvington	12-Jan-2004	25	172	16	
JFP	Battery	21-Nov-2003	9	165	Battery	25-Nov-03	9	165	0	
JFX	Battery	21-Nov-2003	9	177	Battery	25-Nov-03	9	178	0	
JFY	Battery	21-Nov-2003	9	149	Garrison	6-Jan-2004	51	171	42	
JGB	Battery	21-Nov-2003	9	193	Battery	27-Feb-2004	9	207	0	
JGD	Battery	21-Nov-2003	9	184	Battery	24-Nov-03	9	183	0	
JGL	Battery	21-Nov-2003	9	159	Battery	8-Dec-03	9	165	0	
JHX	Battery	21-Nov-2003	9	182	Battery	18-Mar-2004	8	203	1	1

Appendix Table F-1. (Continued)

Tag Number	Release				Recapture				Distance Moved (miles)	Da L
	Station	Date	River Mile	Length (mm)	Station	Date	River Mile	Length (mm)		
IFJ	Battery	24-Nov-2003	9	202	Battery	8-Dec-03	9	209	0	
JEU	Battery	26-Nov-2003	9	196	Battery	19-Mar-2004	7	211	2	1
JMX	Battery	26-Nov-2003	9	190	Battery	23-Feb-2004	9	199	0	
JTM	Battery	4-Dec-2003	9	143	Cornwall	8-Jan-2004	56	147	47	
KEP	Battery	12-Dec-2003	9	208	Battery	31-Mar-2004	8	222	1	1
KFN	Battery	12-Dec-2003	9	196	Battery	6-Apr-2004	9	212	0	1
KFS	Battery	12-Dec-2003	9	183	Battery	15-Dec-03	10	183	1	
KJV	Battery	19-Dec-2003	9	165	West Point-S	5-Jan-2004	51	166	42	
IAE	Battery	7-Nov-2003	8	166	Irvington	6-Jan-2004	25	194	17	
ICS	Battery	14-Nov-2003	8	184	Battery	3-Dec-03	7	194	1	
IOS	Battery	14-Nov-2003	8		Irvington	12-Jan-2004	25	203	17	
IOU	Battery	14-Nov-2003	8	191	Battery	20-Nov-2003	7	193	1	
IOV	Battery	14-Nov-2003	8	187	Battery	24-Mar-2004	8	203	0	1
IPC	Battery	14-Nov-2003	8	163	Battery	19-Nov-2003	7	160	1	
IPT	Battery	14-Nov-2003	8	176	Battery	10-Mar-2004	8	185	0	1
IRK	Battery	14-Nov-2003	8	150	Marlboro	7-Jan-2004	68	162	60	
ISB	Battery	14-Nov-2003	8	178	Battery	22-Dec-2003	8	185	0	
ISK	Battery	14-Nov-2003	8	207	Battery	18-Nov-2003	7	209	1	
ISR	Battery	14-Nov-2003	8	192	Battery	19-Nov-2003	7	195	1	
ISV	Battery	14-Nov-2003	8	181	Battery	3-Dec-2003	7	193	1	
JEN	Battery	21-Nov-2003	8	188	Battery	22-Dec-2003	8	196	0	
IIA	Battery	2-Dec-2003	8	174	Battery	2-Dec-2003	9	183	1	
JTT	Battery	5-Dec-2003	8	196	Battery	8-Dec-2003	9	198	1	
KAW	Battery	11-Dec-2003	8	193	Battery	17-Dec-2003	8	195	0	
KDR	Battery	12-Dec-2003	8	197	Battery	18-Dec-2003	8	198	0	
KGD	Battery	17-Dec-2003	8	183	Battery	23-Dec-2003	9	187	1	
KIT	Battery	18-Dec-2003	8	179	Irvington	7-Jan-2004	25	182	17	
JHX	Battery	18-Mar-2004	8	182	Battery	16-Apr-2004	8	212	0	
IAN	Battery	7-Nov-2003	7	184	Battery	27-Feb-2004	7	206	0	1
IAW	Battery	7-Nov-2003	7	179	Battery	5-Dec-2003	8	192	1	
IBY	Battery	7-Nov-2003	7	194	Battery	26-Mar-2004	8	220	1	1
ICJ	Battery	7-Nov-2003	7	147	Battery	17-Nov-2003	7	151	0	
ICS	Battery	7-Nov-2003	7	184	Battery	14-Nov-2003	8	188	1	

**Appendix Table F-1. (Continued)**

Tag Number	Release				Recapture				Distance Moved (miles)	Da L
	Station	Date	River Mile	Length (mm)	Station	Date	River Mile	Length (mm)		
ICZ	Battery	7-Nov-2003	7	129	Battery	5-Dec-2003	8	140	1	
IDB	Battery	7-Nov-2003	7	170	West Point-N	30-Dec-2003	52	180	45	
IEC	Battery	7-Nov-2003	7	167	Battery	17-Nov-2003	7	175	0	
IEK	Battery	7-Nov-2003	7	155	Battery	18-Nov-2003	7	163	0	
IIA	Battery	11-Nov-2003	7	174	Battery	2-Dec-2003	8	183	1	
IIH	Battery	11-Nov-2003	7	162	Battery	25-Nov-2003	7	170	0	
IUM	Battery	18-Nov-2003	7	179	Battery	2-Mar-2004	7	194	0	1
IUP	Battery	18-Nov-2003	7	173	Battery	22-Dec-2003	7	193	0	
IUS	Battery	18-Nov-2003	7	179	Battery	8-Dec-2003	8	172	1	
IUZ	Battery	18-Nov-2003	7	178	Irvington	7-Jan-2004	25	188	18	
IXG	Battery	18-Nov-2003	7	173	Battery	17-Dec-2003	8	184	1	
JAG	Battery	19-Nov-2003	7	156	Battery	20-Feb-2004	7	172	0	
JAT	Battery	19-Nov-2003	7	193	Battery	22-Mar-2004	7	210	0	1
JCW	Battery	20-Nov-2003	7	183	Cornwall	31-Dec-2003	56	193	49	
JDB	Battery	20-Nov-2003	7	182	Battery	5-Dec-2003	8	190	1	
JDW	Battery	20-Nov-2003	7	186	Battery	9-Dec-2003	7	186	0	
JDX	Battery	20-Nov-2003	7	150	Battery	2-Dec-2003	8	149	1	
JPG	Battery	3-Dec-2003	7	156	West Point-N	9-Jan-2004	52	163	45	
JPN	Battery	3-Dec-2003	7	191	Marlboro	7-Jan-2004	68	195	61	
JVZ	Battery	5-Dec-2003	7	196	Battery	23-Dec-2003	9	196	2	
JYI	Battery	9-Dec-2003	7	182	Battery	18-Dec-2003	7	187	0	
JZC	Battery	9-Dec-2003	7	159	West Point-N	8-Jan-2004	52	164	45	
KJK	Battery	19-Dec-2003	7	207	Battery	2-Mar-2004	7	210	0	



Appendix Table F-2. (Continued)

Release Week	Station Name	River Mile	Mark/Recapture Statistics			Days at Large			Distance between Release and Recapture S									
			M	C	R	Max	Mean	Min	Same Station				Movement North					
									N	Max	Mean	Min	N	Max	Mean	Min		
22 Dec 2003	Highland	76	0	0	0													
	Milton	71	0	0	0													
	Marlboro	68	0	0	0													
	Cornwall	56	0	0	1	8	8	8	1	0	0	0						
	West Point North	52	778	869	16	21	10	1	10	0	0	0	4	16	7	4	2	
	West Point South	51	62	187	1	20	20	20										1
	Garrison	51	0	0	0													
	<b>NORTH</b>	<b>76-51</b>	<b>840</b>	<b>1056</b>	<b>18</b>	<b>21</b>	<b>10</b>	<b>1</b>	<b>11</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>4</b>	<b>16</b>	<b>7</b>	<b>4</b>	<b>3</b>	
	Peekskill	43	0	0	0													
	Indian Point	41	0	0	0													
	Croton	36	0	0	0													
	Nyack	29	4	4	0													
	Tarrytown	27	0	0	0													
	Irvington	25	590	655	3	18	11	7	3	0	0	0						
<b>SOUTH</b>	<b>43-25</b>	<b>593</b>	<b>659</b>	<b>3</b>	<b>18</b>	<b>11</b>	<b>7</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>0</b>							
29 Dec 2003	Highland	76	8	9	0													
	Milton	71	0	0	0													
	Marlboro	68	116	129	3	7	6	5	2	0	0	0						1
	Cornwall	56	298	334	14	32	10	1	13	0	0	0						1
	West Point North	52	1008	1099	17	87	10	1	13	0	0	0	1	4	4	4	3	
	West Point South	51	107	175	2	4	4	3					2	1	1	1		
	Garrison	51	134	148	4	43	12	2	3	0	0	0						1
	<b>NORTH</b>	<b>76-51</b>	<b>1671</b>	<b>1894</b>	<b>40</b>	<b>87</b>	<b>9</b>	<b>1</b>	<b>31</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>4</b>	<b>2</b>	<b>1</b>	<b>6</b>	
	Peekskill	43	0	0	0													
	Indian Point	41	0	0	0													
	Croton	36	11	11	0													
	Nyack	29	0	0	0													
	Tarrytown	27	0	0	0													
	Irvington	25	812	1014	15	28	7	0	13	0	0	0	1	4	4	4	1	
<b>SOUTH</b>	<b>43-25</b>	<b>823</b>	<b>1025</b>	<b>15</b>	<b>28</b>	<b>7</b>	<b>0</b>	<b>13</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>1</b>		

Appendix Table F-2. (Continued)

Release Week	Station Name	River Mile	Mark/Recapture Statistics			Days at Large			Distance between Release and Recapture S									
			M	C	R	Max	Mean	Min	Same Station				Movement North					
									N	Max	Mean	Min	N	Max	Mean	Min		
5 Jan 2004	Highland	76	0	0	0													
	Milton	71	0	0	0													
	Marlboro	68	365	378	0													
	Cornwall	56	383	744	14	9	4	3	13	0	0	0						1
	West Point North	52	742	772	6	32	9	1	5	0	0	0						1
	West Point South	51	65	87	0													
	Garrison	51	84	114	1	86	86	86										1
	<b>NORTH</b>	<b>76-51</b>	<b>1639</b>	<b>2095</b>	<b>21</b>	<b>86</b>	<b>9</b>	<b>1</b>	<b>18</b>	<b>0</b>	<b>0</b>	<b>0</b>						<b>3</b>
	Peekskill	43	3	3	0													
	Indian Point	41	0	2	0													
	Croton	36	10	17	0													
	Nyack	29	257	265	6	18	13	2	6	0	0	0						
	Tarrytown	27	0	0	0													
	Irvington	25	1472	1753	15	51	9	0	12	0	0	0						3
	<b>SOUTH</b>	<b>43-25</b>	<b>1742</b>	<b>2040</b>	<b>21</b>	<b>51</b>	<b>10</b>	<b>0</b>	<b>18</b>	<b>0</b>	<b>0</b>	<b>0</b>						<b>3</b>
12 Jan 2004	Highland	76	0	0	0													
	Milton	71	0	0	0													
	Marlboro	68	97	100	0													
	Cornwall	56	210	233	3	26	12	1	2	0	0	0						1
	West Point North	52	214	226	0													
	West Point South	51	25	37	0													
	Garrison	51	0	13	0													
	<b>NORTH</b>	<b>76-51</b>	<b>545</b>	<b>609</b>	<b>3</b>	<b>26</b>	<b>12</b>	<b>1</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1</b>
	Peekskill	43	0	0	0													
	Indian Point	41	2	2	0													
	Croton	36	30	31	0													
	Nyack	29	291	300	4	32	16	4	2	0	0	0						2
	Tarrytown	27	0	0	0													
	Irvington	25	557	629	5	57	20	1	2	0	0	0	1	4	4	4	4	2
	<b>SOUTH</b>	<b>43-25</b>	<b>879</b>	<b>962</b>	<b>9</b>	<b>57</b>	<b>18</b>	<b>1</b>	<b>4</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>4</b>

Appendix Table F-2. (Continued)

Release Week	Station Name	River Mile	Mark/Recapture Statistics			Days at Large			Distance between Release and Recapture S									
			M	C	R	Max	Mean	Min	Same Station				Movement North					
									N	Max	Mean	Min	N	Max	Mean	Min		
19 Jan 2004	Highland	76	0	0	0													
	Milton	71	0	0	0													
	Marlboro	68	0	0	0													
	Cornwall	56	39	46	3	1	1	1	3	0	0	0						
	West Point North	52	3	3	0													
	West Point South	51	15	18	0													
	Garrison	51	0	0	0													
	<b>NORTH</b>	<b>76-51</b>	<b>57</b>	<b>67</b>	<b>3</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>0</b>						
	Peekskill	43	1	1	0													
	Indian Point	41	0	0	0													
	Croton	36	4	4	0													
	Nyack	29	350	377	6	26	8	2	5	0	0	0						1
	Tarrytown	27	0	0	0													
	Irvington	25	67	69	0													
<b>SOUTH</b>	<b>43-25</b>	<b>422</b>	<b>451</b>	<b>6</b>	<b>26</b>	<b>8</b>	<b>2</b>	<b>5</b>	<b>0</b>	<b>0</b>	<b>0</b>						1	
26 Jan 2004	Highland	76	0	0	0													
	Milton	71	0	0	0													
	Marlboro	68	0	0	0													
	Cornwall	56	1	1	0													
	West Point North	52	1	1	0													
	West Point South	51	1	1	0													
	Garrison	51	0	0	0													
	<b>NORTH</b>	<b>76-51</b>	<b>3</b>	<b>3</b>	<b>0</b>													
	Peekskill	43	0	0	0													
	Indian Point	41	0	0	0													
	Croton	36	0	0	0													
	Nyack	29	144	155	2	4	3	1	2	0	0	0						
	Tarrytown	27	0	0	0													
	Irvington	25	0	0	0													
<b>SOUTH</b>	<b>43-25</b>	<b>144</b>	<b>155</b>	<b>2</b>	<b>4</b>	<b>3</b>	<b>1</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>0</b>							



