Population characteristics of the spiny dogfish, *Squalus acanthias* Linnaeus, 1758, from geographically distinct locations in Atlantic Canada during the summer and fall of 1996

by

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Abstract

A total of 1684 dogfish were sampled to determine population characteristics from three regions in Atlantic Canada: the Minas Basin, the outer Bay of Fundy, and the Gulf of St. Lawrence. The posterior dorsal spine was removed from 211 male and 475 female dogfish for ageing. Ages were determined from the spines and annuli lost to wear were calculated using a spine dimension standardized equation. This study was the first attempt to define a complete reproductive stage assessment of a shark. A total of 475 females had the reproductive tracts removed and categorized as one of six stages. The Minas Basin sample exhibited the highest number of reproductively mature females (56.1%) and female dogfish captured in the outer Bay of Fundy were predominantly immature (97.6%). Maturity for 50% of female dogfish in Atlantic Canada was calculated at 17 years of age and a total length of 83.4 cm. Male dogfish age and total length were similar between the three regions but only 11 male dogfish were taken during the entire season in the Minas Basin (male:female ratio; 1:99). The Minas Basin female dogfish were significantly larger, older, and more mature than females in the other two sampling locations. Few comprehensive studies exist on spiny dogfish in the Northwest Atlantic because it is has only recently been commercially exploited. If commercial exploitation of dogfish were to begin in Atlantic Canada it would be more economically and biologically successful as a bycatch fish with other fisheries.

Introduction

The spiny dogfish, *Squalus acanthias* Linnaeus, 1758, is a common shark of the North Atlantic and North Pacific Oceans. It occurs in the east and west coast of North America including the Bay of Fundy (Scott and Scott 1988). Comprehensive studies on its biology in the Bay of Fundy are non-existent, however, spiny dogfish is a slow growing, cartilaginous fish with a long lifespan. The Atlantic and Pacific populations are spatially separated and some of their characteristics have diverged enough to be considered separate species until recently (Jones and Geen 1976). Nammack et al. (1985) suggested that western Atlantic dogfish live approximately fifty years and reach average maximum lengths of 101 cm for females and 93 cm for males. Female dogfish of the North Pacific are known to live up to 95 years of age and reach lengths up to 124 cm (Ketchen 1975; Wood et al. 1979; Beamish and McFarlane 1985). These differences suggest Pacific dogfish may live longer and grow more slowly than dogfish of the western North Atlantic due to water temperature differences, but this possibility requires further study.

Squalus acanthias occurs in eastern Canadian inshore waters in the spring through fall period, appearing in the outer Bay of Fundy in May-June and departing in November-December (Scott and Scott 1988). Temperature may be the determining factor causing seasonal movements of dogfish. Studies indicate dogfish prefer offshore wintering grounds with temperatures between 6 °C to

11 °C (Jensen 1965).

Tagging studies by Templeman (1944; 1976; 1984), Holland (1957), and Jensen (1961; 1965) indicate dogfish school by size up to maturity and then by size and sex once they have matured. Templeman (1976) also recorded a transatlantic migration of dogfish from Newfoundland, Canada to Iceland.

Most studies have assumed spiny dogfish of the Northwest Atlantic are comprised of a single unit stock (Ford 1921; Templeman 1944; Templeman 1954; Shafer 1970; Nammack et al. 1985; Rago et al. 1994; Hurlbut et al. 1995). Preliminary work off the coast of North Carolina, USA indicates there were external differences between dogfish in the southern and northern range of the stock (Rulifson 1998). Annand and Beanlands (1986) completed protein electrophoresis on dogfish caught from the Gulf of Maine and the Scotian Shelf and found no difference between spiny dogfish from the two areas.

Male and female dogfish in the Atlantic reach sexual maturity at about 10 years of age and have different growth rates thereafter (Holden 1977). Males grow slower than females and are significantly smaller than females after maturity (Jensen 1965).

Spiny dogfish are ovoviviparous, meaning the eggs are hatched internally with no placental attachment to the mother (Holden and Meadows 1968; Ketchen 1972; Holden 1977; Jones and Geen 1977). Fetal development takes 18 - 22 months and from 1 - 25 pups are produced in each pregnancy. The sex ratio of pups is nearly 1:1 (Templeman 1944; Jones and Geen 1977a). There has been no actual data to confirm the season of the year in which mating occurs, but it has been suggested mating occurs between October and January, peaking some time in December (Ford 1921; Templeman 1944; Jensen 1965; Ketchen 1972). It is known mating occurs when water temperatures are low. Further investigation is required to determine the mating season of the spiny dogfish in the Northwest Atlantic.

Males are capable of mating each year and females every second year. Ovulation occurs just after mating and eggs average 4 cm in diameter. Fertilized eggs are enclosed in a capsule or 'candle' for 4 - 6 months, after which the embryos are released into the uterine cavity. Fecundity of the spiny dogfish increases with the size of the mother and varies from 1 to 25 pups (Templeman 1944; Holden and Meadows 1968; Ketchen 1972).

Age determination of all elasmobranchs is a difficult process because they do not possess calcareous otoliths and their scales are too small to determine annual ring formation. Reading annuli externally from the second dorsal spine is the most preferred method for determining the age composition of spiny dogfish populations (Holden and Meadows 1962; Ketchen 1975; Jones and Geen 1977a; Chilton and Beamish 1982; Soldat 1982; McFarlane and Beamish 1987).

The spine originates from the vertebral column, passes through the dorsal muscles and skin anterior to each dorsal fin. The portion embedded within the muscle is a cartilage rod, which keeps the spine in place. The spine consists of an outer enamel layer, a pigment layer, three layers of dentine, and a central pulp cavity (Slauson 1982). The annulus forms because the dentine layers do not grow at the same rate as the upward growth of the spine. When spine growth is reduced, pigments are concentrated and the enamel layer thickens, producing an annulus (McFarlane and Beamish 1986). McFarlane and Beamish (1986) have identified these bands to be annual with oxytetracycline (OTC) injections from 18 recaptured dogfish. Only 1 out of the 18 recaptures did not show valid annuli with the OTC injections. Counting annuli is still very subjective and there are inconsistencies in ages due to the long lifespan and lack of adequate hard body parts.

The spiny dogfish is an opportunistic feeder whose diet includes fish, crustaceans, molluscs, and coelenterates (Templeman 1944; Holden 1965; Jones and Geen 1977b; Bonham 1984; Bowman 1984; Annand 1985; Nammack et al. 1985). Studies have shown 60 - 70% of the diet of dogfish over 60 cm in length were teleost fish. Their feeding habits reflect the abundance trends of certain fish species rather than preference (Bonham 1984). Consumption estimates and annual food intake of spiny dogfish by Bowman et al. (1984) suggest that dogfish predation may be increasing the mortality of commercially valuable species.

A large number of dogfish enter the inner Bay of Fundy during the summer - fall (Dadswell et al. 1984a). These fish are relatively easy to capture and are considered a nuisance or undesirable species by fishermen and the public in Atlantic Canada (Templeman 1944; Salsbury 1986; Hurlbut et al. 1995). A preliminary study off Newfoundland in 1978 determined dogfish could not be commercially exploited in Canadian waters (Mercer et. al. 1979). In Great Britain and New Zealand, dogfish are a part of the local fish and chip market (Templeman 1944; Aasen 1964; Holden 1968; Salsbury 1986). Since 1990, the states of North Carolina, Virginia, Maryland, and Massachusetts, USA have developed a dogfish fishery, exporting mainly to the European markets. In January 1998, The National Marine Fisheries Service considered spiny dogfish over-harvested in the Northeast USA (NOAA, NMFS 1998).

Commercial fishermen in the USA are concerned that dogfish could become over-harvested before adequate biological data can be collected on this species (Jeff Gearhart pers. comm.). Northwest Atlantic spiny dogfish landings have increased from 519 metric tonnes (mt) in 1963 to 22 572 mt in 1993, with catches mostly from the United States and Canada. In the US, recorded landings have increased from under 500 mt in 1989 to over 20 000 mt annually since 1993 (Rago et al. 1994).

An experimental dogfish fishery was conducted in the fall of 1985 in the Scotia-Fundy region by the Department of Fisheries and Oceans. The experiment was designed to determine if small draggers could land economically feasible catches of quality dogfish. The groundfish bycatches exceeded the dogfish catches three to one and the idea to begin a directed dogfish fishery with drag gear in Atlantic Canada was ended (Salsbury 1986).

Comprehensive dogfish sampling in the inner Bay of Fundy and Minas Basin has never before been attempted. The project will be of use to the Department of Fisheries and Oceans because it will provide information from a stationary sampling location on a non-commercial fish with no general annual assessment in Atlantic Canada.

The population characteristics of spiny dogfish, including: weight-length relationship, growth, reproductive state, percent maturity, and fecundity from morphological measurements and migration from tagging were studied. Data collected on groundfish surveys with the Department of Fisheries and Oceans in the southern Gulf of St. Lawrence N249 survey, the outer Bay of Fundy and its approaches N246 survey were compared to the Minas Basin samples. The final goal was to describe the basic population characteristics for this species and to determine if there were differences among dogfish in Atlantic Canada.

Materials and Methods

Location

The Minas Basin is located in the inner region of the Bay of Fundy along the province of Nova Scotia, Canada (Figure 1). The Bay of Fundy is known for the highest semi-diurnal tides in the world measured at maximum heights of 17.2 m off Burncoat Head of the Minas Basin (Larsen and Topinka 1985). The high tides are a result of the resonance between the oceanic tidal period and the natural period of the Bay of Fundy and the Gulf of Maine and the funnel effect created from the shape of the bay (Larsen and Topinka 1985).

All samples were taken and tags fixed between July 7, 1996 and October 10, 1996 using a 6.5 m research vessel. Dogfish were captured with either 22 mm longline hooks or gill nets of varying mesh sizes in the southern Bight of the Minas Basin between Blomidom Point and Boot Island (45.18N 65.42W) (Figure 1). One day of otter trawling with local fishermen was completed in Baxter's Harbour, NS (45.19N 65.30W) and shoreset gillnets were placed along Evangeline Beach (45.08N 65.41W) and Avonport Beach (45.06N 65.58W) to compare to other capture methods (Figure 1). Drift gillnets of varying mesh sizes were set off the research vessel throughout the season mainly for bait capture.

For comparison to the Minas Basin samples, special samples of dogfish were caught aboard the N246 and N249 groundfish surveys from July 4 - 16, 1996 and September 3 - 27, 1996. These surveys are conducted annually by the

Department of Fisheries and Oceans (DFO). Both surveys were aboard the 51m, RV Alfred Needler. Random set locations were selected prior to departure for both cruises according to DFO sampling protocols. The N246 survey was within the 4W and 4X NAFO divisions (Figure 2), along the eastern coast of Nova Scotia, approaches to the Bay of Fundy, and the Gulf of Maine. The N249 survey was conducted by DFO in the southern Gulf of St. Lawrence region of the 4T division (Figure 3).

Capture Methods and Measurements

All dogfish were measured for total length (TL) and fork length (FL) to the nearest 0.5 cm. Total length was determined as the length of the fish from the end of the snout to the tip of the upper lobe of the caudal fin when depressed to align with the longitudinal axis. Fork length was determined as the distance from the end of the snout to the central curve of the caudal fin. Weight was measured to the nearest 0.1 kg while at sea using a spring fish scale. The scale was calibrated using standardized one pound weights from laboratory balances. All posterior dorsal spines were removed from the sacrificed dogfish for ageing and if female, their reproductive tracts were removed and frozen for later analysis of the reproductive state.

A longline system was developed for sampling between Evangeline Beach and Blomidom Point, Minas Basin. The longline contained approximately 60, 25 mm hooks and soak time was 45 - 90 minutes. American shad (*Alosa* *sapidissima* (Wilson, 1811)) caught in gillnets in the Minas Basin and in the Annapolis River, NS were cut up as bait for the hooks. Winter skate (*Raja ocellata* Mitchell, 1815) and dogfish were the only species caught using this method. Over 25% of the total number of marked dogfish were captured onboard a local flounder fishing vessel owned and operated by a local commercial fisherman from Delhaven, NS on August 28, 1996. Three separate tows were made using a 125 mm diamond otter trawl mesh, 24 m across within Baxter's Harbour, NS (Figure 1). The tows lasted 15 minutes, 30 minutes, and 10 minutes at 42 m depth. One Atlantic cod (*Gadus morhua* Linnaeus, 1758) was caught and released, and 12 winter flounder (*Pseudopleuronectes americanus* (Walbaum, 1792)) were kept as part of the fishermen's fishing quota.

Drift monofilament gillnets with stretch mesh sizes, 100 mm, 115 mm, 115 mm, and 125 mm were set off the research vessel in the Minas Basin for bait capture and as another method for capturing dogfish. Only American shad and 37 striped bass (*Morone saxatilis* (Walbaum, 1792)) were captured with this method. The shad were used as bait for the longline and the striped bass were returned to the water. Shoreset gillnets, the other method used to compare to the longline method, were not effective in capturing dogfish. The shoresets comprised of three monofilament gillnets with 115 mm, 125 mm, and 138 mm stretch mesh and were anchored during low tide off Evangeline Beach for one week and Avonport Beach, NS for two days. The nets were checked at each low tide for fish. The Evangeline shoresets did not capture any fish. Three dogfish were captured during the two day set along Avonport Beach. This method was not effective enough in capturing dogfish to continue its use.

For the N246 and N249 DFO surveys a 20m otter trawl using 127 mm diamond mesh was towed behind the vessel for 30 minutes at each predesignated location. If the location was not adequate due to inappropriate physical characteristics (i.e.: rocky bottom) then a predesignated alternate station was used for the tow. For each tow 10 male and 10 female dogfish were set aside for sampling. All dogfish were measured for total length and fork length to the nearest centimetre, weight in kilograms to the nearest 0.01 kg using an electronic balance, the posterior dorsal spine was removed and the reproductive tract was removed from the females for later lab analysis.

Mark and Recapture Methods

All dogfish, in good condition, that were captured in the Minas Basin from July 7, 1996 to August 28, 1996 were measured for FL and TL to the nearest 0.5 cm, sex identified, marked with a tag, and released back into the water. A FT-1 Floy Dart tag was placed anterior to the first dorsal spine. Dogfish not in adequate condition to be returned to the water were sacrificed for further measurements, and reproductive tract and posterior dorsal spine removal.

Recapture location, date of recapture, and any other information given from the returned tags were recorded. The distance travelled from the Minas Basin tagging location to the recapture location was measured using a chartometer by the Kueffel and Esser Company. The chartometer is an instrument which measures the distance of a line using a tracing wheel calibrated to a graduated dial (Welch 1948). The wheel can be traced over a map to estimate the distance travelled along a pathway. The chartometer was calibrated using a 12 inch ruler. All measurements were taken in inches and converted to metric because the map was scaled in inches. Distances were traced along the coastline instead of a straight path since it was more likely the fish were travelling along the coastline than directly to the recapture location. These were only estimates of the actual distances travelled since it was not certain where the fish went between tagging and recapture.

Spine Removals and Ageing Techniques

The second dorsal spine was removed by placing the knife posterior to the spine. A cut was made parallel to the base of the spine down into the muscle tissue about 5 cm deep (Figure 4(a)). A second cut was anterior to the spine at a 45° angle was made into the tissue until reaching the first cut (Figure 4(b)). The spine was removed, placed into a labelled envelope, and frozen until later lab analysis. If the second dorsal spine was not adequate due to wear or damage, then the first dorsal spine was removed.

In the lab, the excess tissue around the base was excised and the spines were left to air dry for at least 24 hours. Amoural™, a vinyl cleaner normally used for car interiors and tires, was sprayed on the spines for further cleaning and to produce a shine which facilitated easier visualisation of annual ridges under the enamel layer. The spine grows in a series of dentine cones. Each cone represents one year with annual pigment bands forming between the enamel and dentine layers at the base of each cone (Slauson 1982; Figure 5).

Using Vernier calipers, all spines were measured for their spine length (SL), wear length (WL), spine base diameter (SBD), and wear point diameter (WPD) to the nearest 0.1mm (Figure 6). Under a light dissecting microscope, at 6.4 power and dark background, the annuli for each spine were counted from the spine base diameter to the wear point diameter (Ketchen 1975). There were problems counting the annuli on worn or damaged spines, as was the case in many other studies (Holden and Meadows 1962; Ketchen 1975; Chilton and Beamish 1982; Beamish and McFarlane 1985).

Calculations of Worn Spine Age and Growth

Annuli lost to wear were calculated by the method developed by Ketchen (1975). All spines with a wear diameter of 0 to 1.5 mm had their spine base diameter (mm) plotted against age (years). The diameter of 1.5 mm was determined as the spine base diameter at birth. Spines with wear points less than 1.5 mm were considered have no lost annuli. The curve of best fit was estimated from the equation:

$\text{Age} = b(\text{Spine base diameter})^{m}$ (Ketchen 1975)

where,

m = slope of the curve

b = y-intercept of the curve.

This equation was used to determine the number of years lost to wear from spine base diameters of worn spines. Two years were subtracted from this calculation before adding the number of lost annuli to the years counted from the spine base diameter to the wear point diameter because of the two year gestation period in which the spine would grow to about 1.5 mm in diameter. Ketchen's method was preferred for more accurate ages of dogfish because Nammack et al. 1985 found it better to compensate for lost annuli than rejecting worn spines.

The ages determined from Ketchen's method were used to obtain the von Bertalanffy growth relationship. The equation for the von Bertalanffy growth relationship is:

$L_t = L_\infty(1 - e^{-K(t - t_0)})$(Ricker 1975)

where,

L_t = total length (cm) at time t

L_∞ = theoretical maximum length in the population

t = age of the fish

t_0 = a parameter for time when the total length equals zero

K = Brody growth coefficient

A computer generated curve fit of this equation was calculated from the observed data. The von Bertalanffy growth equation was fitted for dogfish captured on the N246 survey, the N249 survey, and in the Minas Basin, for both males and females. The von Bertalanffy growth relationship was also determined for all males and all females captured during the summer-fall of 1996.

The weight-length relationship for males and females was obtained by plotting the weight (kg) against the total length (cm) of the fish. The equation for the weight-length relationship is:

$$\log(\text{weight}) = a + b^{*}\log(\text{total length})$$ (Ricker 1975)

where,

a = y-intercept of the regression line

b = regression coefficient.

The weight - total length relationship was plotted for the N246 survey, the N249 survey, and the Minas Basin for males and females. Overall, weight-length relationships for male and female dogfish was determined for the Atlantic Canada. The slope and standard error of each weight - total length relationship was compared between study locations to determine significant differences in growth. The equation to determine growth differences was:

$$t_{\text{calculated}} = \frac{\beta_1 - \beta_2}{S_1 - S_2}$$ (Steel and Torrie 1960)

where,

β_1 = regression coefficient for a study location

β_2 = regression coefficient for other study location

S_1 = standard error for β_1

S_2 = standard error for β_2

$\sqrt{}$ = square root of the entire denominator

The $t_{calculated}$ value was compared to the $t_{critical}$ value at alpha = 0.05 to determine if there were significant differences between the growth of male and female dogfish captured in the three study locations in Atlantic Canada (Steel and Torrie 1960).

Reproductive Tract Removal and Measurements

In all sacrificed females, whether immature or mature, the reproductive tracts were removed and placed in labelled bags for later analysis. The reproductive tracts consisted of the ovary, oviduct, and uterus. Using a knife or scissors, the ventral surface of the female was opened starting from the urinary pore and ending at the base of the pectoral fin (Figure 7).

Six stages of reproductive maturity and state in females were identified. The six stages are:

Stage I - Immature: no developing eggs, oviduct very thin and straight within the wall of the body cavity (Figure 8).

Stage II - Immature, with developing eggs: eggs having diameters > 20 mm, oviduct thin and straight within the wall of the body cavity (Figure 9).

Stage III: Candle Stage: membrane surrounding embryos and their yolk sacs, very fragile, breaks open easily. Looks like a "candle". According to the literature this stage represents the first 4 - 6 months after fertilization (Figure 10) (Templeman 1944; Holden and Meadows 1968; Ketchen 1972; Jones and Geen 1977).

Stage IV: Post Candle Stage: Candle membrane no longer evident, embryos and attached yolks free-floating within the uterine cavity. Embryos measuring +16 mm in length, sex determination of embryos not possible, and developing eggs in the ovaries <20 mm in diameter (Figure 11).

Stage V: Pup Stage: Can determine the sex of the individual pups. Pups look like small adults, and reach maximum total lengths up to 39.8 mm. Yolk sacs attached to the pups become smaller as they reach the end of the gestation period. Developing eggs in the ovaries >20 mm in diameter (Figure 12).

Stage VI: Spent Stage: Uterine cavity flaccid. Eggs in the ovaries developed to 40 mm in diameter (Figure 13).

In the lab, the reproductive tracts were thawed and assigned to one of the six stages. The diameter of the eggs in the ovary were measured using Vernier callipers to the nearest 0.1 mm for reproductive tracts of Stages II to VI. The total length of embryos of Stage III and Stage IV were measured to the nearest 0.1 mm. The sex, total length (cm) and fork length (cm) to the nearest 0.5 cm, and weight (g) to the nearest 0.1g were determined for the pups in Stage V of reproductive development.

Fecundity, Maturity, and Embryo Development

Fecundity is defined as the number of progeny in the female before the next mating period (Caillet et. al. 1986). An estimation of fecundity was determined by plotting the number of progeny against the total weight (kg) of the mother to determine the curve of the form:

$F = ax^b$ (Ricker 1975)

where,

F = fecundity

a = a constant

x = total maternal weight (kg)

b = an exponent, which is close to 1 when related to weight.

The curve was transformed into a straight line by logarithmic transformation:

$\log(F) = (b)\log(x) + \log(a)$.

Calculations of this line were developed for females captured from the N246 survey, the N249 survey, the Minas Basin, and for all three regions combined.

Mature female dogfish were considered fish with reproductive tracts described either as Stage III, Stage IV, Stage V, or Stage VI. Total maternal weight (kg) was plotted against the percent maturity of females within the weight parameter. A logistic curve fit was calculated to the data to determine the total number of the females at 50% maturity for the N246 region, the N249 region, the Minas Basin region, and all three areas combined.

The mean total length with the standard error for all embryos and pups within

Stage III, Stage IV, and Stage V was determined for each region and for all three areas combined. The mean egg diameter with their standard error for ovarian eggs in either Stage II, Stage III, Stage IV, Stage V, or Stage VI were determined for all separate study locations and the three locations combined.

Analysis of Variance of Total Length, Age, and Maturity of Dogfish in the Three Study Locations

The median total length and median age of male and female dogfish were analysed for significant differences between the three study locations using the Kruskal-Wallis test by SigmaStat©(Tuerke et. al. 1993). The Kruskal-Wallis test is a non-parametric one way analysis test of variance on ranks. This non-parametric test was chosen over other tests because normality failed in the observed data and the population distributions were somewhat similar for all three locations. For this test the only assumption were the population distributions were continuous and the same shape (Farrell 1997; Netter and Wasserman 1974). The total length and age distrtibutions for both male and female dogfish were mostly skewed left.

Three categories determined the percent maturity of female dogfish dependent on the maternal weight. The ranges for the maternal weight were: 0.5 - 1.49 kg, 1.5 - 2.49 kg, and $\geq$ 2.5 kg. These values were then analysed using the Kruskal-Wallis rank test to determine significant differences among the three maternal weight ranges of the three separate study locations.

Estimation of Growth Parameters

All computer generated curve fits were calculated using Sigma Plot© by Jandel Scientific (Tuerke et al. 1993). Jandel Scientific uses the Marquardt-Levenberg algorithm to find the coefficients for the best fit of the equation to the actual data. The algorithm verifies the parameters to minimize the sum of the square differences between the observed and predicted values of the data.

All data for males and females were separated because of the difference in size after maturity. Calculations were also determined separately for dogfish capture on the N246 survey, the N249 survey, and in the Minas Basin.

Results

General Population Characteristics

A total of 1115 spiny dogfish were captured off the research vessel in the Minas Basin, from July 7, 1996 to October 10, 1996 (Table 1). Of these captured dogfish, 751 were marked and released, and 364 were sacrificed for reproductive tract and spine removal. An additional 244 dogfish were captured aboard a local flounder fishing vessel in Baxter's Harbour, NS on August 28, 1996, marked and released (Figure 1). A total of 216 spiny dogfish were sampled during the N246 DFO survey and 114 during the N249 DFO survey at various set locations (Figure 14; Figure 15).

The ratio of males to females captured at each of the three regions differed (Figure 16; Figure 17). On the N246 DFO survey, 1:0.7 males to females were captured. On the N249 DFO survey, 1:1.5 males to females were captured. The Minas Basin dogfish collections were predominantly female. A total of 1.0:99.2 males to females were captured at this location.

Female dogfish ranged in total lengths from 51 - 87 cm on the N246 survey, from 64 - 101 cm on the N249 survey, and from 64 - 113 cm in the Minas Basin. Male dogfish ranged in total lengths from 53 - 86 cm on the N246 survey, from 64 - 87 cm on the N249 survey, and from 74 - 86 cm in the Minas Basin (Figure 16; Figure 17; Table 2). The age range for female dogfish captured on the N246 survey was 3 - 36 years, on the N249 survey from 9 - 27 years, and in the Minas

Basin from 10 - 34 years. Male dogfish ranged from ages 2 - 29 years on the N246 survey, from 9 - 24 years on the N249 survey, and from 10 - 21 years in the Minas Basin (Figure 18; Figure 19; Table 2). The age range was much wider for both male and female dogfish captured on the N246 survey compared to the other two locations. Younger dogfish were captured on the N246 survey compared to dogfish captured in the Minas Basin and on the N249 survey.

Normality failed in all comparisons (Female TL: $p < 0.0001$; Male TL: $p < 0.0001$; Female Age: $p < 0.0002$; Male Age: $p = 0.0036$) (Table 3). Total lengths and ages of females varied significantly among the three locations (Female TL: $p < 0.0001$; Female Age: $p < 0.0001$; Male Age: $p = 0.0217$). The total lengths of males were significantly different ($p < 0.0001$) between the three regions but the ages were not ($p = 0.5038$).

Weight-Length Relationship and Growth Comparisons

The weight-length relationships of female spiny dogfish for the three study locations were similar (Figure 20) as they were for male spiny dogfish (Figure 21). The combined weight-length relationship for female spiny dogfish from Atlantic Canada was:

$$\log(W) = 3.5\log(TL) - 6.1;\ r^2 = 0.94$$

and for male dogfish was:

$$\log(W) = 2.8\log(TL) - 5.1;\ r^2 = 0.93$$

where, weight was measured in kilograms and total length in centimetres (Figure

22).

Female dogfish varied more in weight than males at similar lengths. The Minas Basin female dogfish varied more in their weight-length relationship than the N249 or N246 female dogfish. The b-values ranged from 3.2 - 3.4 meaning they exhibited allometric growth, therefore they were growing slightly more in weight than they were in length (Ricker 1975). Male spiny dogfish did not have as high b-values (between 1.6 - 2.9) therefore weight was not increasing as much as length.

Growth, using the weight-length relationship, was equal for male and female dogfish among the three regions, except the between male dogfish from the N246 DFO survey and the Minas Basin ($t_{calculated}$ = 2.2580; Table 4). This comparison may not be valid due to the small sample size of male dogfish captured in the Minas Basin and not directly related to differences in growth between males captured in the two regions.

Age and Growth

A total of 644 spines were analyzed during this study: 344 from the Minas Basin, 200 from the N246 DFO survey, and 100 from the N249 DFO survey. The spine base diameters (SBD) of spines $\leq$ 1.5 mm in diameter were standardized for age (years) to determine the equation of best fit for annuli loss (Figure 23). This equation was used to determine the number of annuli lost to wear in older spines (Ketchen 1975). Male dogfish have an equation for annuli loss of:

$\text{Age} = 1.4(\text{SBD})^{1.5}$; $r^2 = 0.49$.

The female dogfish equation for annuli loss was determined as:

$\text{Age} = 1.8(\text{SBD})^{1.3}$; $r^2 = 0.52$.

The spine base diameter for all wear points greater than 1.5 mm were standardized into either of these equations depending on the sex of the individual to determine the number of lost annuli. The calculated number of lost annuli were added to the ages determined on the spines' external readings from the SBD to the point of wear. The new ages were used to determine the von Bertalanffy growth equation for male and female dogfish at all three study locations and the study locations combined (Figure 24; Figure 25; Figure 26; Table 5).

The asymptotic length, L_∞, was smallest for both male ($L_\infty = 77$) and female ($L_\infty = 80$) dogfish captured during the N246 DFO survey and greatest in the Minas Basin (male $L_\infty = 81$; female $L_\infty = 97$). The birth size, t_0, was close to 2 for most von Bertalanffy growth equations, ranging from 1.9 - 2.8 for female dogfish and from 1.7 - 2.13 for male dogfish in the three regions. The Brody growth coefficient, K, was between 0.14 and 0.20 for female dogfish in the three regions and between 0.22 and 0.27 for males captured in the three regions. A larger K for males indicates faster growth for male dogfish than for female dogfish.

For all three regions combined, the von Bertalanffy growth equation for female dogfish was:

$L_t = 91(1 - e^{-0.17(t - 2.5)})$

and for male dogfish captured in all three study locations:

$L_t = 78(1 - e^{-0.25(t - 1.8)})$(Figure 26).

Maturity

Female dogfish captured in the Minas Basin were found to be in all stages of development with 56% of the total sample reproductively mature (Table 6). Female dogfish captured during the N246 DFO survey were almost completely immature (97.6%). Female dogfish from the N249 survey showed all but Stage II of reproductive development and 72% were immature.

In the Minas Basin, most of the mature females were captured in the early part of the run from July to late August. The majority of the immature females in the Minas Basin were captured from September to October. Most of the males captured in the Minas Basin were not taken until October.

A frequency distribution of maternal fish weight (kg) to percent maturity determined the weight of female dogfish at 50% maturity for the three study regions and the regions combined (Figure 27; Figure 28). Fifty percent maturity of the sampled female dogfish on the N246 and N249 DFO surveys were both 2.9 kg weight or 90.6 cm and 85.1 cm total length. Age at 50% maturity for female dogfish on the N246 survey was 26 years and for female dogfish on the N249 survey 17 years. Female dogfish from the N246 DFO survey were mostly immature (97.6%) (Table 6), therefore age at 50% maturity was overestimated probably from lack of mature females in the sample. In the Minas Basin 50%

maturity was calculated to be at a weight of 2.7 kg, total length of 82.4 cm, and age of 16 years. For all three study locations combined 50% maturity was reached at a weight of 2.7 kg or total length of 83.4 cm. The mean age of female dogfish at 50% maturity in Atlantic Canada was about 17 years.

The percent maturity in relation to maternal total weight between the N246 DFO survey, the N249 DFO survey, and the Minas Basin collections were categorized into three maternal total weight categories: from 0 - 1.49 kg, 1.5 - 2.49 kg, and 2.5 - all above weights. There were no differences between the 0 - 1.49 kg female weight category for the three study locations because samples were all immature in this weight range. There were no statistically significant differences between the maturity of females within the 1.5 - 2.49 kg weight range in all three study locations (Kruskal-Wallis; $p = 0.2124$). Female dogfish categorized $\geq$ 2.5 kg in total weight, showed a statistically significant difference between the median % maturity values for the three study locations (Kruskal-Wallis; $p = 0.0338$). This indicated that maturity was different among the regions in Atlantic Canada. Female dogfish in the Minas Basin were more mature than female dogfish captured in the outer Bay of Fundy and Gulf of St. Lawrence.

Fecundity and Reproductive Development

Litter sizes ranged from 1 - 11 embryos, with an average of 5.23 embryos per mature female (Figure 30). There was variability in the number of embryos per female of any given weight at all study locations. Minas Basin females had the most variable litters (Figure 29). Fecundity was represented for the N246 DFO survey, the N249 DFO survey, and the Minas Basin combined as:

$$\log(\text{Number of progeny}) = 0.8\log(\text{Total maternal weight}) + 0.3$$

Embryonic lengths measured from 16.1 - 398.0 mm in total length, with a mean total length of 39.8 mm for Stage III embryos, 72.3 mm for Stage IV embryos, and 224.8 mm for Stage V pups (Table 7). A total of 232 pups were male and 235 pups were female. There was no significant difference between size of male or female pups in Stage V development (Mann-Whitney; $p = 0.3137$).

Migration

A total of 17 recaptures were obtained from 995 spiny dogfish tagged during 1996 in the Minas Basin with an average of 276 days at large and an average distance traveled of 569 km (Figure 31; Table 8). Recaptures were 0.02% of the total number of spiny dogfish marked and released in the Minas Basin. Most recaptures were returned just after the opening of a local fishery.

Four recaptures were returned off Yarmouth, NS at the beginning of the winter lobster fishery started in December (#1694, #1190, #1646) and after the beginning of the April lobster season opening (#1580 and #1294). The Sandy Cove, NS tag (#1640) was captured in a herring weir and one off Port Maitland, NS (#1274) was captured by handline.

The Rhode Island and Cape Cod tag returns (#1264, #1053, and #1702) were captured just after the local dogfish fishery opened and another tag (# 212) from the same area was captured by rod and reel. Tag #212 traveled the longest distance, 1056 km, in only 144 days. This dogfish traveled an average of 7.3 km per day. The Gloucester, Massachusetts tag returns (#1226, #1904, and #1901) were captured just after the opening of their local dogfish fishery. Only two tags were returned from the Minas Basin close to the tagging location (#1425) on May 26, 1997 and the other in the Avon River on August 6, 1997 (#1480). The tag at liberty for the longest time (#1159) was captured off Grand Manan, NB, 630 days after release. Tag #1264 was captured on the same day twice. First by a NOAA groundfish survey vessel and later by a local commercial fisherman off Cape Cod.

Discussion

General Population Characteristics

The Bay of Fundy is a unique ecological system and provides an important link in the life history processes of many fish species along the eastern North American coastline (Dadswell et al. 1984a). The inner reaches of the Bay of Fundy are warmer in the summer than other localities on the Canadian east coast and may be uilized by fish with specific life history needs (Bousefield and Liem 1958). Spiny dogfish have never before been studied in the Bay of Fundy, or compared to other regions in Atlantic Canada. This study has indicated variations exist among spiny dogfish aggregations at different geographical regions in Atlantic Canada and these differences may be due to life history strategies of the local dogfish stock.

Female dogfish captured in the Minas Basin were larger and more mature than females captured during the Scotian Shelf survey or during the Gulf of St. Lawrence survey. Spiny dogfish caught during the N246 DFO survey were taken mostly in the outer approaches of the Bay of Fundy, very few were present along the Nova Scotian shelf or the offshore region at that time of the year. Female spiny dogfish captured in the Gulf of St. Lawrence were somewhat similar in their size range to females in the Minas Basin, but were not as reproductively mature.

There was a 99:1 ratio of females to males in the Minas Basin. Mature females were most predominant at the early and middle periods of the run in the Minas Basin and as the season progressed, immature females and males became more common. Mature females may have been entering the Minas Basin, seeking the warmer waters found there during the summer, to assist internal growth of their offspring (Bousefield and Liem 1958). Spiny dogfish have one of the longest gestation periods of any vertebrate species, from 22 - 25 months (Ford 1921; Templeman, 1944; Jensen 1965). Other studies have indicated that mature dogfish tend to be closer inshore, which is generally a warmer region of the ocean, than immature dogfish (Jensen 1965; Nammack et al. 1985; Hurlbut et al. 1995). The large number of female dogfish in the Minas Basin indicates that the Bay of Fundy may be a significant location in Atlantic Canada for the reproductive success of this species.

Growth

Compared to two other studies in the Northwest Atlantic (Slauson 1982; Nammack et al. 1985) the maximum asymptotic length (L_∞) for all three locations obtained during this study were lower and the growth coefficient (K) was usuallly higher. The highest L_∞ was 97 cm for female dogfish in the Minas Basin, whereas Slauson (1975) and Nammack et al. (1985) calculated an L_∞ greater than 100 cm for female dogfish off Massachusetts and Rhode Island. The K values were also lower for females in these other studies at 0.07 and 0.09, therefore growing slower, as compared to 0.14 and 0.20 for female dogfish captured in the Minas Basin and during the N246 DFO survey. From this information, it can be assumed dogfish in the northern range had a lower mean asymptotic total length but grew at a faster rate than the southern relatives.

Nammack et al. (1985) and Slauson (1982) both found negative t_0 values for their von Bertalanffy equations of dogfish growth but in this study t_0 was positive. Their studies did not account for the gestation period and t_0 began at birth instead of at conception. It is more appropriate to consider growth beginning after conception in the uterus, and embryo lengths can be incorporated in to the von Bertalanfy growth equation.

Lower L_∞ than the observed lengths may indicate my sample size was not large enough at the higher end of the growth range. Also, L_∞ could have been acting as only the mean maximum size for the entire population. Larger individuals would be expected in an unexploited stock above this average size (Nammack et al. 1985). Males have a greater K value than females, therefore males reach their theoretical maximum length (L_∞) sooner and grow faster than females. From my growth curve estimations the calculated time when fish length equals zero (t_0) for males and females was close to 2 years which is equivalent to the time pups grow before birth within the mother.

The weight-length relationship of male and female dogfish are similar up to about 50 cm total length and then greater for females after this length (Nammack et al. 1985). Male dogfish tend to grow isometrically throughout their entire lifetime. Female dogfish grow isometrically up to maturity and show mostly allometric growth after maturity. Females tend to grow larger and vary more in size after maturity because of pregnancy. The number of pups per pregnancy increases with the age of the female dogfish (Templeman 1944; Jensen 1965; Holden 1977; Jone and Geen 1977a).

Ageing

Accurate age determination of fishes is an important requirement in assessing and achieving proper management strategies for any commercially exploited species. It is helpful to know the size and age at which a species become sexually mature so fishing can be restricted and reproduction can occur before being exposed to harvesting pressure. All elasmobranchs are a difficult group for determining age, growth, and reproduction because they are elusive, have minimal commercial value, and possess few anatomical structures for accurate age verification.

Age determination using the second dorsal spine of the spiny dogfish has been utilized in other studies (Kaganovskaia 1933; Templeman 1944; Aasen 1964; Holden and Meadows 1962; Ketchen 1975; Soldat 1982). Spiny dogfish are one of the few elasmobranch species in which dorsal spine circuli have been directly validated as annual, but only for the Canadian west coast stock (Beamish and McFarlane 1985). Age validation has not been conclusively shown for spiny dogfish of the Northwest Atlantic.

This study found spiny dogfish captured in Atlantic Canada ranged in age from 2 - 36 years of age. Maximum ages were younger than anticipated from the literature. Other studies in the Northwest Atlantic have suggested that spiny dogfish can live up to 50 years of age but have only demonstrated age counts up to 35 years (Slauson 1982; Nammack et al. 1985). Jones and Geen (1977a) noted Ketchen's technique (1975) of compensating for missing annuli of worn tips produces better results than rejecting worn spines (Nammack et al. 1985). Variations in length at age is attributed to the difficulty in interpreting rings along the spine and individual differences among the populations.

One method not examined during this study which is often used for mammals is measuring the weight of the eye lens. The eye lens is an ectodermal structure which grows throughout the lifetime of the organism and its mass should be proportionate to the length and age of the organism (Friend 1968). Due to the lens position in the body it does not undergo wear like many other structures used for age determination (Morris 1972). Siezen (1989) has determined a relationship between lens weight and age of spiny dogfish from measurements of lens weight, body length, and spine base diameter. This method has also proven effective in ageing smooth dogfish, *Mustelus canis* (Mitchill, 1815) (Zigman and Yulo 1979). Eye lens verification in dogfish could be used to increase the accuracy of the spine technique and create a standardized ageing technique for all elasmobranchs.

Reproduction and Maturity

It is important to develop stages for the gestation period in order to determine the timing for conception, and for assessing more accurately, recruitment into the dogfish population. This is a first attempt to determine a general reproductive assessment in stages for a shark species. Since most female dogfish captured in the Minas Basin were in Stage III and Stage V of reproductive development this would indicate that mating occurred between November to March, following Jensen's (1965) observations. The mating season, if there is one, for spiny dogfish is still relatively uncertain. Male spiny dogfish were more prevalent in offshore areas so it would be reasonable to suggest mating occurs offshore (Ford 1921; Templeman 1944; Jensen 1965; Slauson 1982).

Embryonic growth and development in Atlantic Canada was similar to other studies in the Northwest Atlantic (Ford 1921; Templeman 1944; Slauson 1982). Pupping or the birth of the young may be seasonal. Female dogfish in Stage III and Stage V in Atlantic Canada during the summer, estimates conception occurred no later than February. Evidence of spent females later in the season (October) could indicate the Minas Basin as a pupping ground for this species. It can be suggested from this study the pupping season for females coming to Atlantic Canada occurs anywhere between October to February.

Dogfish from the Pacific have had an estimated 50% maturity at 29 - 31 years of age (Ketchen 1972; Jones and Geen 1977). Templeman (1944) suggested that 50% maturity was reached at 12 years of age for dogfish captured off Newfoundland. Maturity for 50% of the female dogfish was estimated between 16 - 26 years of age by this study. Dogfish in the Northwest Atlantic appear to be maturing at a faster rate than the west coast stock. Variation in the age of 50% maturity is likely due to changes in environmental conditions (Hanchet 1988; Saunders and McFarlane 1993). It has also been suggested that most fish species do not mature at a certain size or age but along a certain range of ages and lengths, dependent upon the level of environmental stress encountered (Stearns and Crandall 1984). These observations may also be appropriate for spiny dogfish.

Spiny dogfish have been known to vary in maturity and fecundity within small geographical areas, like the west coast of Canada (Ketchen 1972), the Northeast Atlantic (Holden and Meadows 1968), and even in the southern hemisphere (Hanchet 1988). Environmental stress could be considered variation in food supply, constant fluctuations in water temperature, storm activity, or even fishing pressure on other species in which dogfish prey upon.Therefore, dogfish under environmental stress could have slower growth and reach maturity later in one part of the population or have faster growth and earlier maturity in another part of the population. The Northwest Atlantic is known to be one of the most environmentally fluctuating part of the world oceans (Hildebrand 1984), therefore spiny dogfish aggregations can vary within Atlantic Canada, as shown in this study.

Management of Spiny Dogfish

Most of the literature suggests spiny dogfish comprise of one unit stock in the Northwest Atlantic (Ford 1921; Templeman 1944; Shafer 1970; Nammack et al. 1985; Rago et al. 1994; Hurlbut 1995), but no accurate genetic research has been completed to verify this assumption. Evidence indicates that dogfish in different regions have unique fecundity and growth rates, and migration depends on the maturity of the fish (Nammack et al. 1985; Anderson 1990). Spiny dogfish are known to have at least two separate stocks in waters off British Columbia in Georgia Strait and Hectate Strait (Ketchen 1975). Three separate stocks existed in British waters known as the Scottish-Norwegian Stock, the Channel Stock, and the Atlantic Stock (Holden 1965).

In my study there were two defined groups traveling from the Minas Basin. One group moved and overwintered in the area off the southeast coast of Nova Scotia and another continued south to Massachusetts in the Cape Cod region along the coastline. It can be suggested that there may be more than one unit stock in Atlantic Canada. Preliminary observations of dogfish captured off the coast of North Carolina have indicated some morphological differences to the northern relatives, and there may be northern and southern stocks (Rulifson 1998). Fisherman from North Carolina also believe there is an aggregation of spiny dogfish in the deeper coastal waters that remains year round and the group is a nuisance to fisherman after other commercial species in these waters (Roger Rulifson pers. comm.). Accepting there is more than one unit stock would change the approach to management of this species in a sustainable harvest level along the Atlantic coast.

Annual DFO survey results in Atlantic Canada have shown an increase in spiny dogfish abundance since 1987 (Hurlbut et al. 1995). Inshore fishermen regard spiny dogfish as a nuisance, that interferes with fishing operations more than any other species. Spiny dogfish abundance has been so great to temporarily stop fishing activities in areas of the Bay of Fundy (Bernard Millett pers. comm.). The ecological role of spiny dogfish on other species has not been assessed. It has been suggested that the increase in spiny dogfish abundance is the reason for the decline of many commercially valuable species in Atlantic Canada. A directed fishery for spiny dogfish to counteract this supposed decline of other fish species on a large enough scale in Atlantic Canada has been suggested but never implemented (Mercer 1979; Hurlbut et al. 1995).

A large scale directed dogfish fishery along the east coast of the United States for the past eight years has become a lucrative industry with most of the catch exported to Europe and Asia (NOAA, NMFS 1998). The markets demand large dogfish, and catches have predominantly consisted of pregnant females. Since the Minas Basin dogfish stock is comprised mainly of mature females it would be an ideal economical and efficient target location to begin a directed dogfish fishery for the current world market. It may not be economically feasible to create a large scale directed dogfish fishery in Atlantic Canada, but it could become a bycatch fishery. Dogfish captured during other directed commercial fishery operations could be brought in to market as a bycatch incidence fish to reduce its abundance and nuisance to fishermen. This study will provide critical biological information for management of the spiny dogfish stock granted it becomes a commercially exploited species in Atlantic Canada.

Spiny dogfish abundance should not be attributed to the decline of other commercial species such as cod. Dogfish have been indicated in many papers as the cause for declining stocks of other species (Salsbury 1986; Rago et al. 1994; Hurlbut 1995). Dogfish are opportunistic and eat many different species without distinct preferences. A study just released from the Northeast Fisheries Science Center of Woodshole, Massachusetts, spring and autumn trawl surveys from 1993 - 1997, contains information about the stomach contents of spiny dogfish. Of 8400 stomachs sampled during the spring and autumn surveys, only 14% contained fish species (NOAA, NMFS 1998). Ctenophores and crustaceans represented the most frequent species identified in the stomachs of dogfish. The surveys indicated a majority (40 - 46%) of the dogfish stomachs were empty probably due to regurgitation. Food contents in dogfish stomach were not scientifically identified in this study, but it was noted that many were full of crabs common to the Minas Basin. In areas where dogfish are abundant and regarded as a nuisance, they should not be reduced in biomass solely on the basis that they may predate on more commercially acceptable species. More accurate information on the feeding habits of spiny dogfish should be obtained before a fishery is established to determine the ecological role of spiny dogfish in food web.

The abundance of spiny dogfish of the Northwest Atlantic stock has increased since the 1960s (Rago et al. 1994; Hurlbut 1995). In 1977, The Magnuson Act was established and landings decreased significantly due to the exclusion of foreign vessels in US waters. With the beginning of a dogfish fishery in Massachussets, Virginia, and North Carolina in 1990, landings have since increased by a factor of four. Also, the number of discards have increased and depending on the percentage of the discards which die, then the level of the current fishing mortality could be much higher than recorded. The total catch in 1993 was 36 000 mt but may have been as high as 50 000 mt (Rago et al. 1994). The spiny dogfish population of the Northwest Atlantic has probably declined in abundance due to increased exploitation (Hurlbut et al. 1994; Rago et al. 1994; NOAA, NMFS 1998). Length frequencies from both USA commercial landings and research vessel surveys indicate a decline in the average length of females (Rago et al. 1994). The median weight for females landed since the beginning of this fishery has dropped by 1.5 kg (NOAA, NMFS 1998).

Spiny dogfish are sensitive to overfishing due to their life history patterns. Stock and recruitment are directly related and litter sizes may increase to a point as stock density decreases (Holden and Meadows 1968). Uncertainty exists on the data and parameters used in assessing and managing the Northwest Atlantic spiny dogfish stock. More accurate information is needed on total catch estimates with both catch and discard data, and more sex and length characterization of the total catch (Rago et al. 1994).

This past winter spiny dogfish were considereded an overharvested species by the National Marine Fisheries Service in the United States with little information from the southern end of the range to justify this declaration (NOAA, NMFS 1998). This study will provide a basic overview of the life history of spiny dogfish in Atlantic Canada and provide information at the northern end of the range for the stock.

A management program with appropriate targets for stock biomass and fishing mortality should be established. The model developed by Wood et al. (1979) for the British Columbia stock was the only age structured model applied successfully to elasmobranchs. The model was initially used for marine mammals and due to similarities in life history patterns, it could be used for elasmobranchs. Wood et al. (1979) concluded from the model that mortality is a a density -dependent factor of the changes in the stock caused from exploitation. It has been shown in whale stocks that recruitment changes greatly and influences sustainable yields at different stock levels. Further analysis is necessary to determine if change in stock levels influence similar biological parameters in sharks, such as spiny dogfish, as they do in whale stocks (Anderson 1990).

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Tables

Table 1: Summary of the fish captured in the Minas Basin during the summer - fall 1996.

Dates	Number tagged dogfish	Number sacrificed dogfish	American shad	Winter skate	Striped bass	Method
June 30			10		26	Gillnet
July 7	29	3		5		Longline
July 8			11		11	Gillnet
July 10	81	7		10		Longline
July 12	36	2		2		Longline
July 16	11	1		2		Longline
July 18	85	20		8		Longline
July 19	51	4		7		Longline
July 23	118	9		3		Longline
July 27	68	3		13		Longline
July 28	72	5		6		Longline
Aug. 3	105	12		23		Longline
Aug. 6	73	10		12		Longline
Aug. 8	20	2		2		Longline
Aug. 12		1				Shoreset
Aug. 13		2				Shoreset
Aug. 13		33		2		Longline
Aug. 21		20		4		Longline
Aug. 22	2	39		2		Longline
Aug. 28	244			23		Otter Trawl
Aug. 31		24		2		Longline
Sept. 8		79		8		Longline
Sept. 21		30		4		Longline
Sept. 29		33		4		Longline
Oct. 10		25		2		Longline
TOTAL	**995**	**364**	**21**	**144**	**37**	

Table 2: Summary of total length range (cm) and age range (years) of male and female dogfish captured in the three sampling locations.

	Total length range (cm)		**Age range (years)**	
	females	**males**	**females**	**males**
N246 survey	51 – 87	53 – 86	3 – 36	2 – 29
N249 survey	64 – 101	64 – 87	9 – 27	9 – 24
Minas Basin	64 – 113	74 – 86	10 – 34	10 – 21

Table 3: Results of the Kruskal-Wallis one way analysis of variance of ranks between total length (cm) and age (years) of male and female dogfish captured at the three study locations. TL = Total Length

Groups	Median value	Normality	P - value	Significant difference
Female TL				
N246	71.0	Failed	$P < 0.0001$	Yes
N249	81.0	$P \leq 0.0001$		
Minas Basin	90.0			
Male TL				
N246	71.0	Failed	$P < 0.0001$	Yes
N249	75.0	$P < 0.0001$		
Minas Basin	78.5			
Female age				
N24 6	15.0	Failed	$P < 0.0001$	Yes
N249	18.0	$P < 0.0002$		
Minas Basin	21.0			
Male age				
N246	15.0	Failed	$P = 0.5038$	No
N249	16.0	$P = 0.0036$		
Minas Basin	15.0			

Table 4: Analysis of growth between male and female dogfish in the three study locations in Atlantic Canada.

Comparisons	$t_{calclculated}$	**Equal growth or not equal growth**
FEMALES		
N246 - Minas Basin	0.0982	Equal
N246 - N249	1.0684	Equal
N249 - Minas Basin	1.0563	Equal
MALES		
N246 - Minas Basin	2.2580	Not Equal
N246 - N249	1.0389	Equal
N249 - Minas Basin	1.5774	Equal

Table 5: The von Bertalanffy growth parameters determined for spiny dogfish for the present study and other studies in the Northwest Atlantic.

	Sex	**L_∞**	**K**	**t_0**
Present study				
Minas Basin	M	83	0.24	2.13
	F	97	0.14	2.80
N246 survey	M	77	0.27	1.98
	F	80	0.20	1.90
N249 survey	M	81	0.22	1.70
	F	87	0.17	2.20
All 3 locations	M	78	0.25	1.80
	F	91	0.17	2.50
Slauson 1975	M	85.48	0.14	-1.96
	F	120.96	0.07	-2.75
Nammack et al. 1985	M	82.49	0.18	-2.67
	F	100.50	0.09	-2.90

Table 6: Percent number of female dogfish in the reproductive development stages for the three study locations during the summer - fall 1996.

Reproductive development	Percent females N246 survey	Percent females N249 survey	Percent females Minas Basin
Stage 1	95.2	72.3	35.8
Stage 2	2.4	0	8.1
Stage 3	0	16.9	18.4
Stage 4	0	1.5	2.9
Stage 5	2.4	4.6	24.2
Stage 6	0	4.6	10.6

Table 7: Summary of egg diameter ranges (mm), embryo total length range (mm), and male and female dogfish pups total length range (mm) in the various reproductive development stages.

Reproductive development	**Egg diameter (mm)**	**Embryo total length (mm)**	**Mean embryo total length (mm)**	**Pup total length (mm)**	
				female	**male**
Stage 2	20.8 – 41.6				
Stage 3	18.2 – 64.4	16.1 – 71.6	39.8		
Stage 4	11.4 – 71.6	40.4 – 97.8	72.3		
Stage 5	17.2 – 43.3	176 – 398	224.8	176 – 326	174 - 398
Stage 6	23.1 – 40.5				

Table 8: Summary of tag recoveries from spiny dogfish marked in the Minas Basin during July 8 – August 28, 1996.

Tag number	Date tagged (1996)	Date captured	Days at large	Location captured	Distance travelled (km)
1. 1264	July 23	Nov. 2/96	93	42.10N 70.01W	801
2. 1694	July 19	Dec. 21/96	160	43.19N 67.09W	432
3. 1190	July 23	Dec. 21/96	155	43.39N 66.57W	416
4. 1053	July 10	Dec. 1/96	144	41.06N 71.30W	1056
5. 1646	July 18	Dec. 29/96	164	43.00N 65.43w	554
** 1264	July 23	Nov. 2/96	93	42.05N 70.15W	
6. 212	August 28	Feb. 25/97	153	44.05N 66.17W	1049
7. 1580	July 8	Apr. 9/97	275	43.50N 65.45W	395
8. 1226	July 27	May 12/97	289	42.36N 70.10W	736
9. 1425	July 28	May 24/97	300	45.12N 64.20W	3
10. 1904	August 28	May 3/97	248	42.37N 70.00W	736
11. 1294	July 23	Jun. 6/97	317	43.60N 66.60W	599
12.1901	August 28	Jul. 12/97	318	42.40N 71.00W	820
13.1480	July 31	Jul. 31/97	363	45.05N 64.10W	29
14.1640	July 18	Aug. 6/97	384	44.30N 66.05W	401
15. 1274	July 23	Aug. 12/97	385	43.58N 58.66W	416
16. 1702	August 6	Jun. 10/97	308	41.54N 68.54W	881
17. 1159	July 23	May 15/98	630	44.27N 66.42W	348
Average			**276**		**569**

** Tag captured twice on the same day first by NOAA Survey and returned to the water, then later by a fisherman who kept the fish and the tag.

Figures

Figure 1: The Minas Basin sampling locations for dogfish captured from July 7, 1996 to October 10, 1996.

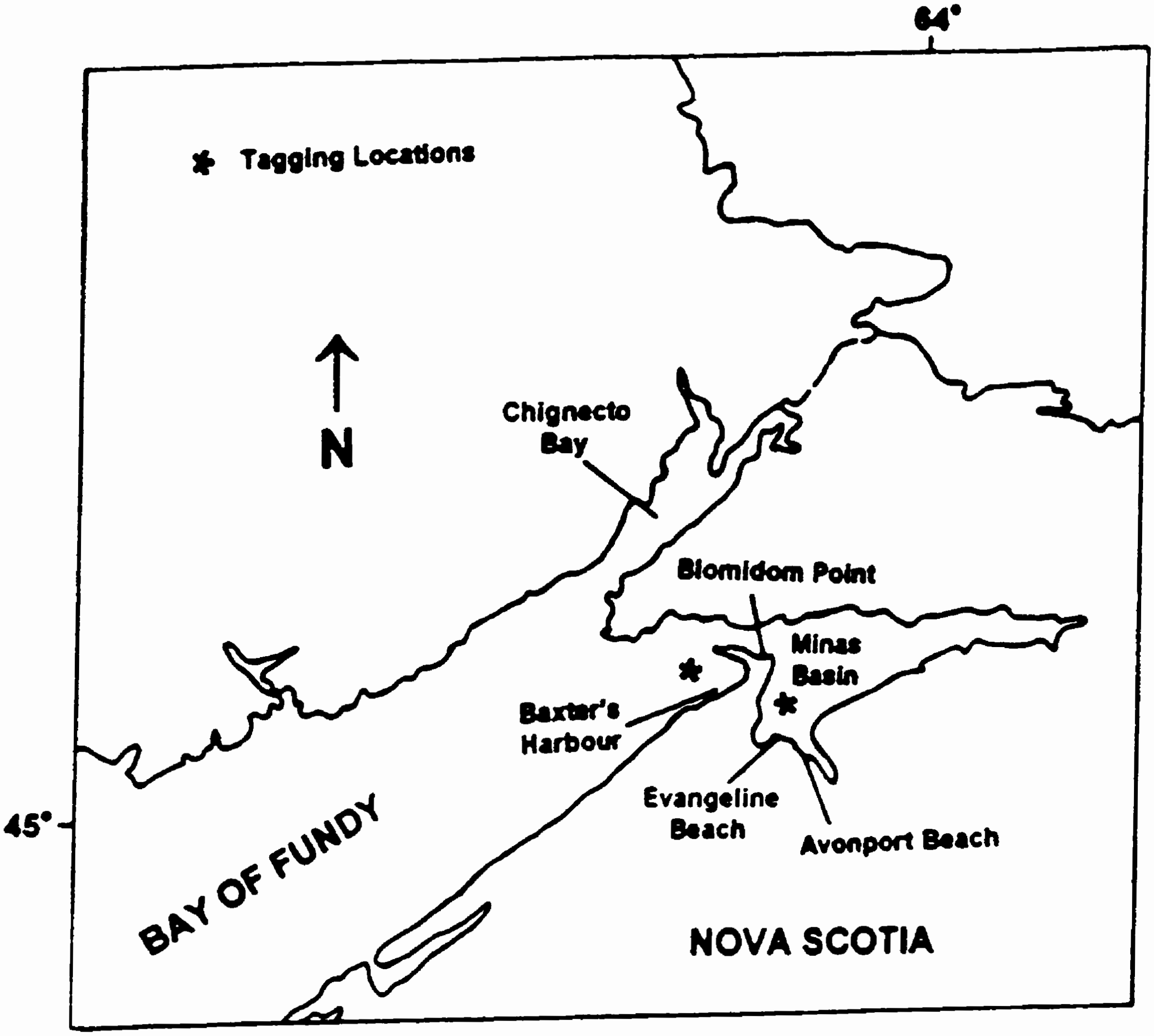

64°
* Tagging Locations
N
Chignecto Bay
Blomidom Point
Minas Basin
Baxter's Harbour
Evangeline Beach
Avonport Beach
45°
BAY OF FUNDY
NOVA SCOTIA

Figure 2: The N246 DFO survey area and set locations for spiny dogfish captured during July 1996.

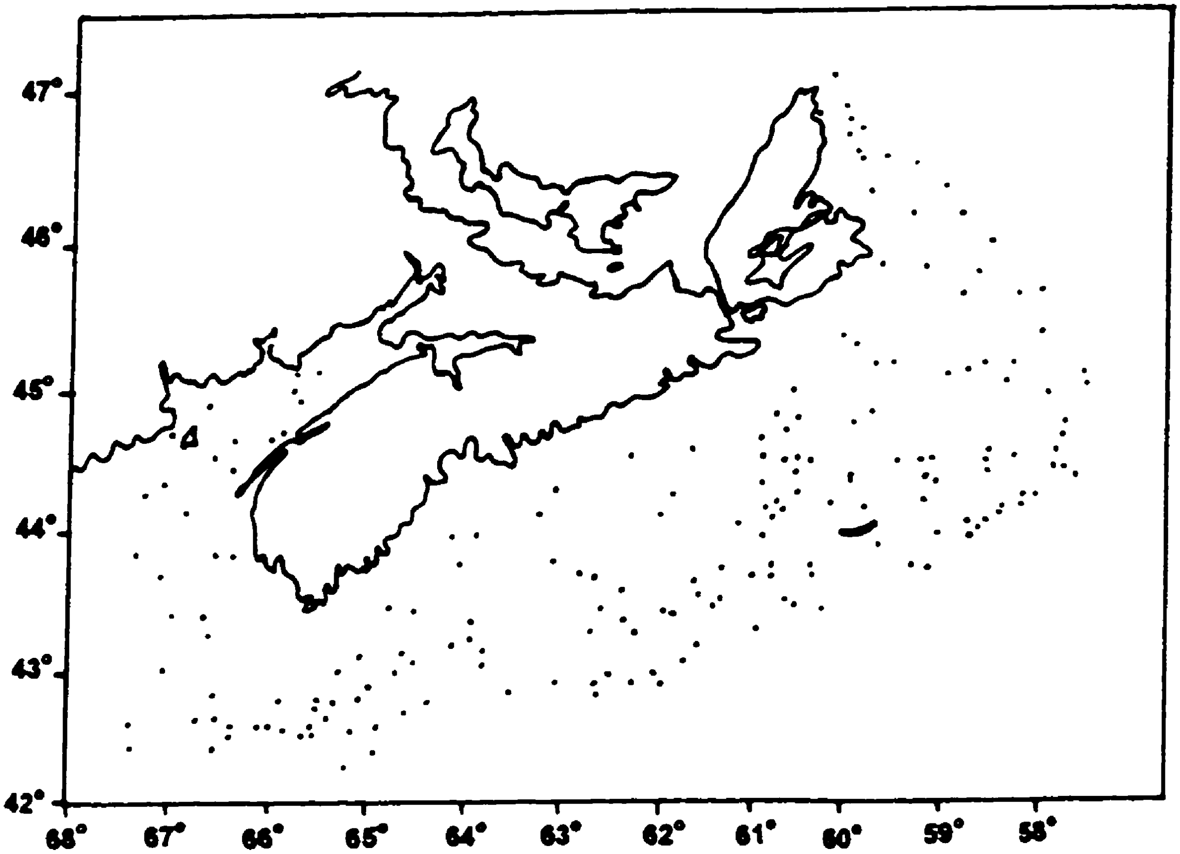
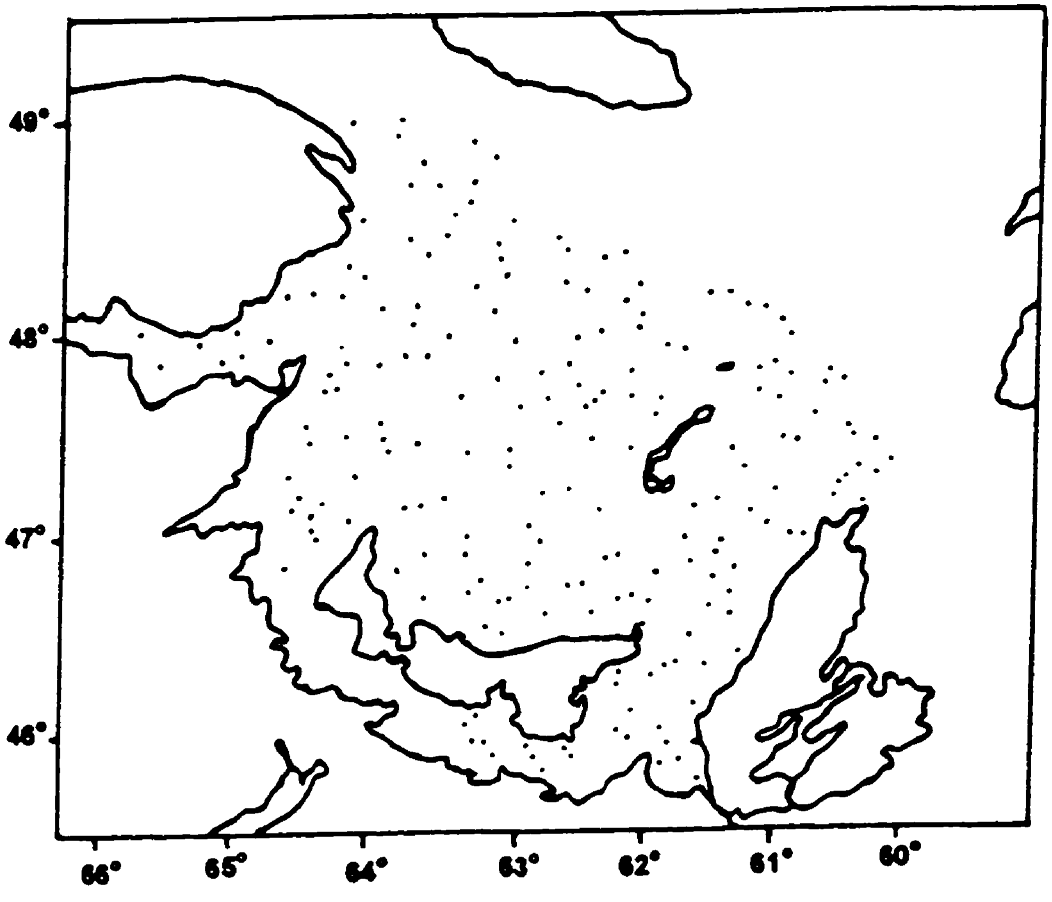

47°
46°
45°
44°
43°
42°
68°
67°
66°
65°
64°
63°
62°
61°
60°
59°
58°

Figure 3: The N249 DFO survey area and set locations for dogfish captured during September 1996.



49°
48°
47°
46°
66°
65°
64°
63°
62°
61°
60°

Figure 4: Posterior dorsal spine removal in the spiny dogfish for an age estimate.

a = first cut; b = second cut.

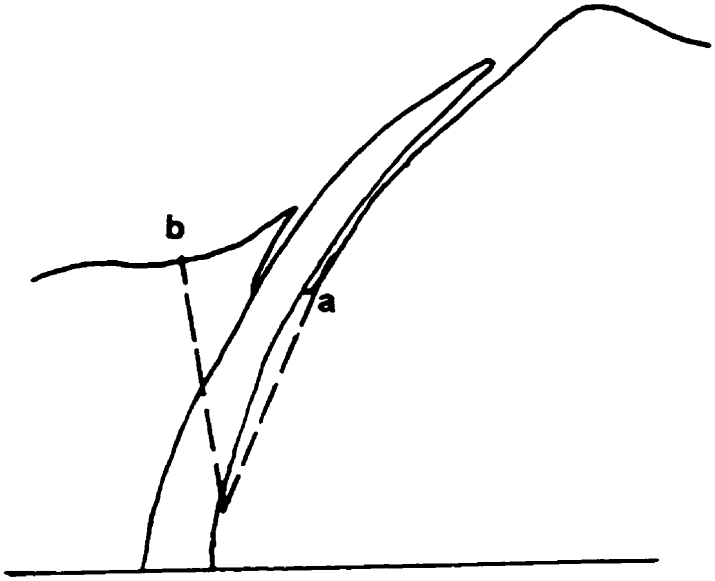

b
a

Figure 5: Longitudinal schematic diagram of the posterior dorsal spine (a) and spine growth showing five annual opaque rings or bands at the cone bases (b)(Slauson 1982).

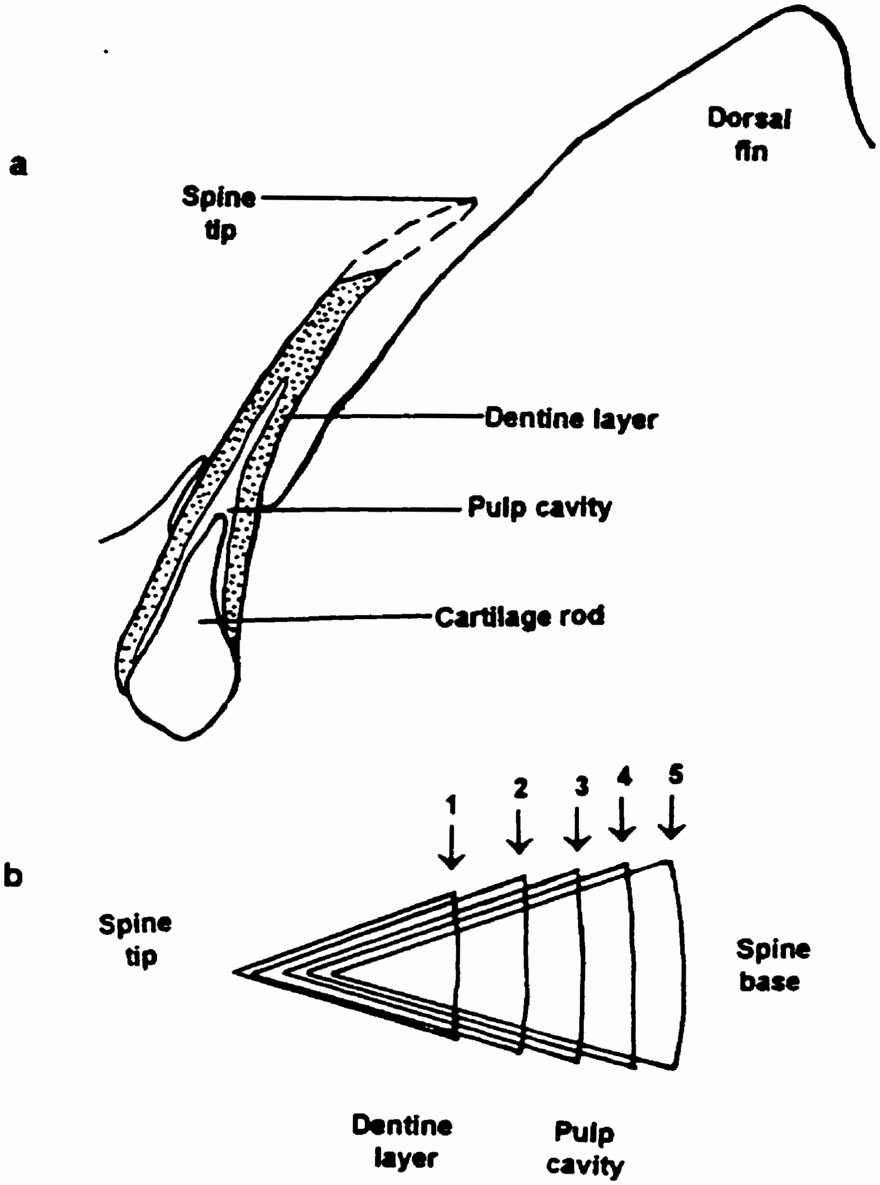

a
Dorsal fin
Spine tip
Dentine layer
Pulp cavity
Cartilage rod
b
1
2
3
4
5
Spine tip
Spine base
Dentine layer
Pulp cavity

Figure 6: Measurements taken from the posterior dorsal spine of the spiny dogfish. SL = Spine Length; WL = Wear Length; SBD = Spine Base Diameter; and WPD = Wear Point Diameter .

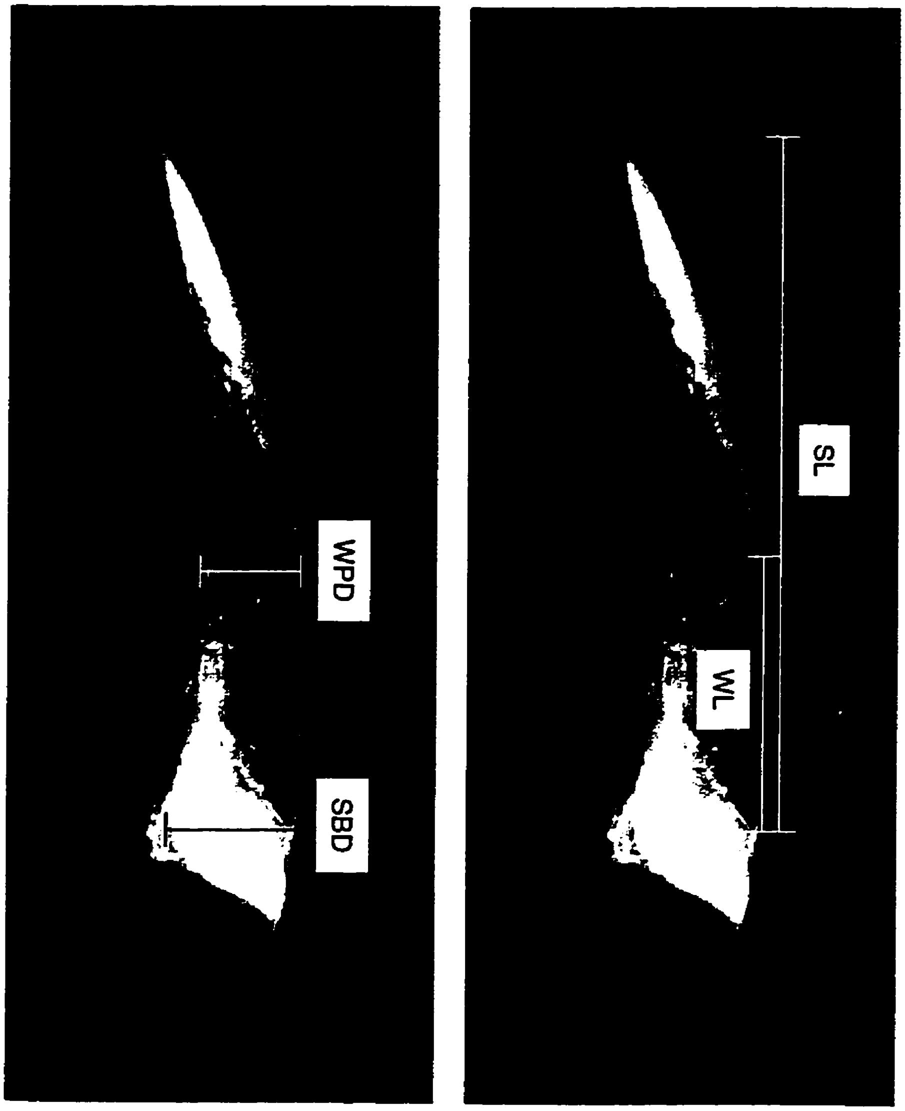

WPD
SBD
SL
WL

Figure 7: Reproductive tract removal in the female spiny dogfish.

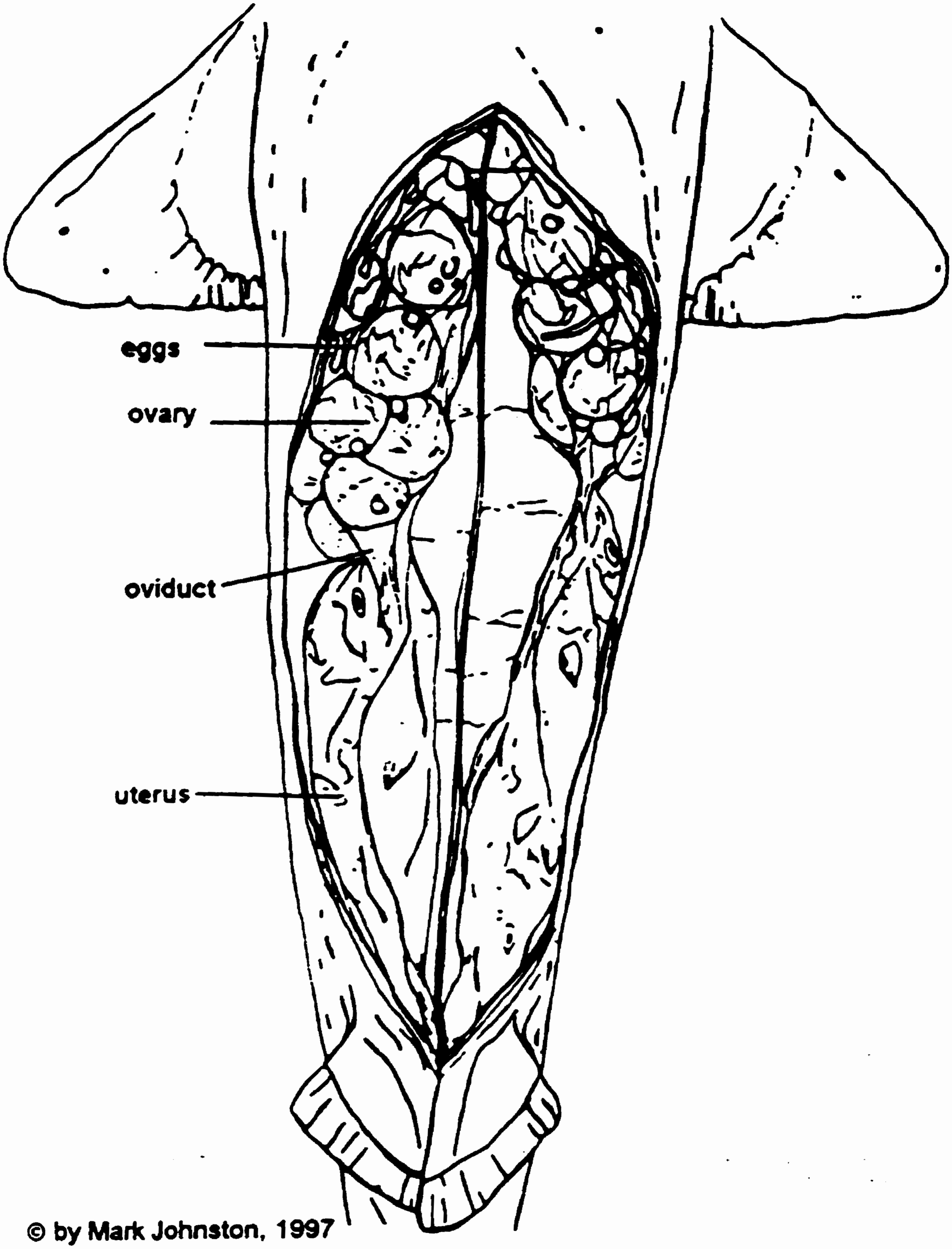

eggs
ovary
oviduct
uterus

Figure 8: Stage I of reproductive tract development in the female spiny dogfish.

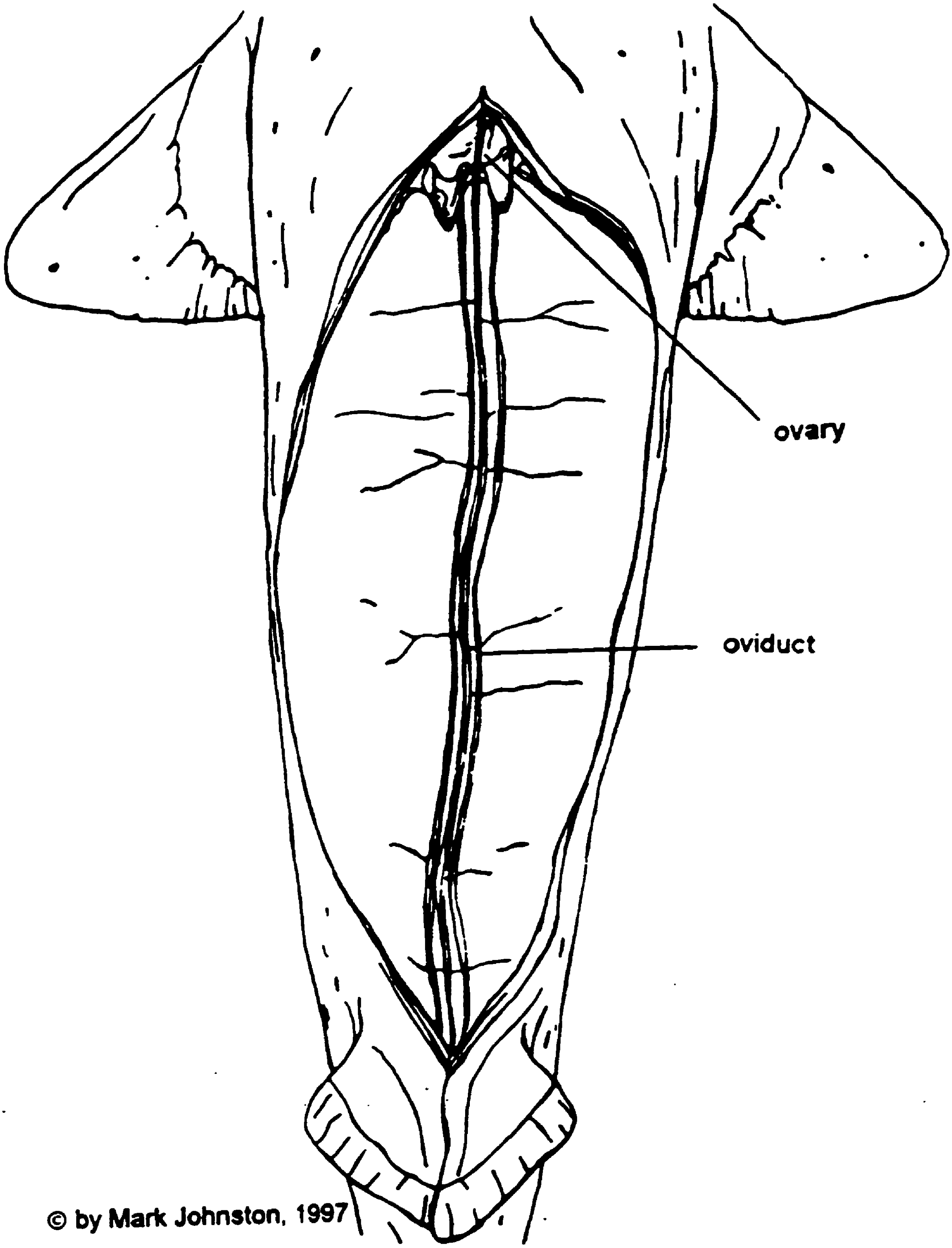

ovary
oviduct

Figure 9: Stage II of reproductive tract development in the female spiny dogfish.

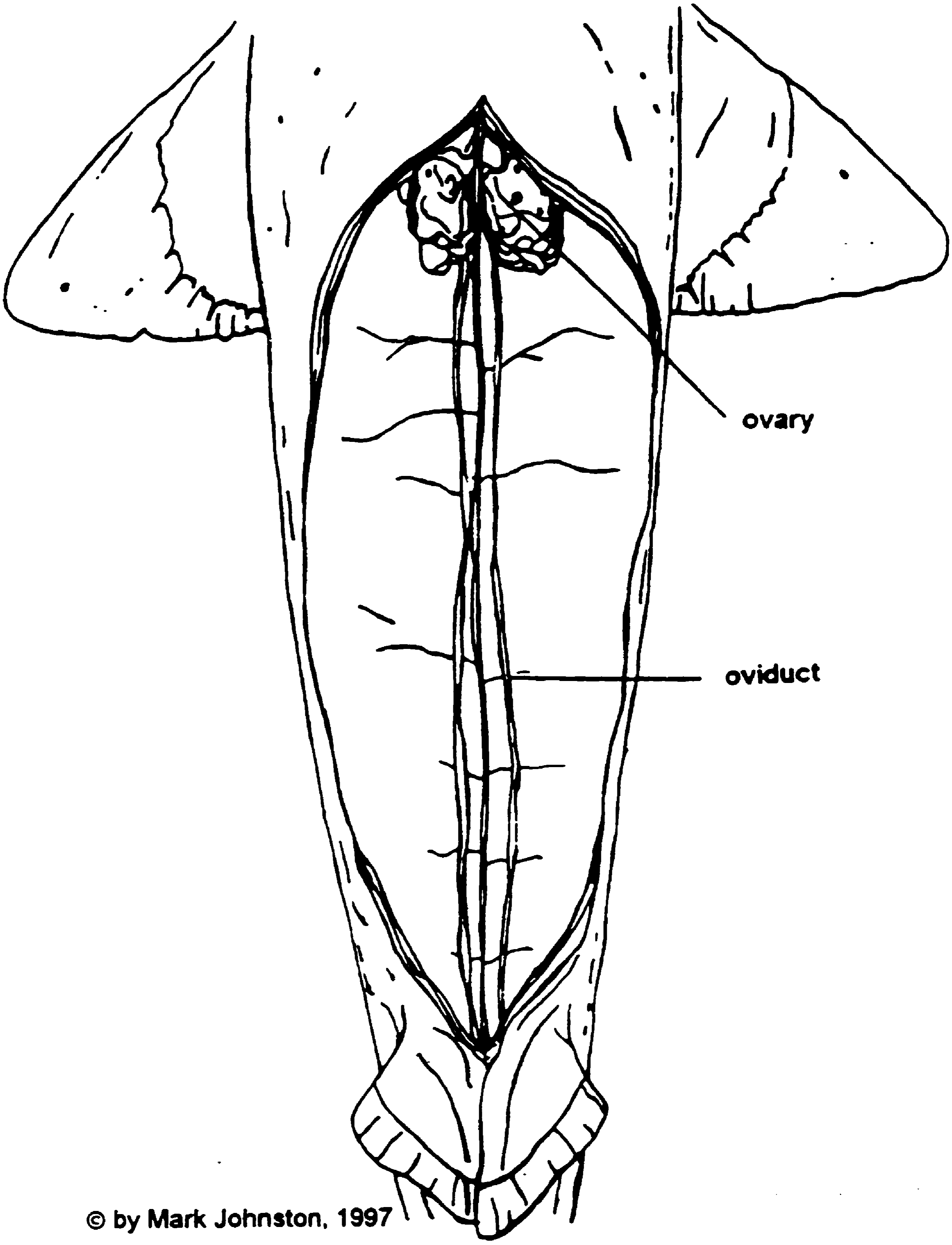

ovary
oviduct

Figure 10: Stage III of reproductive tract development in the female spiny dogfish.

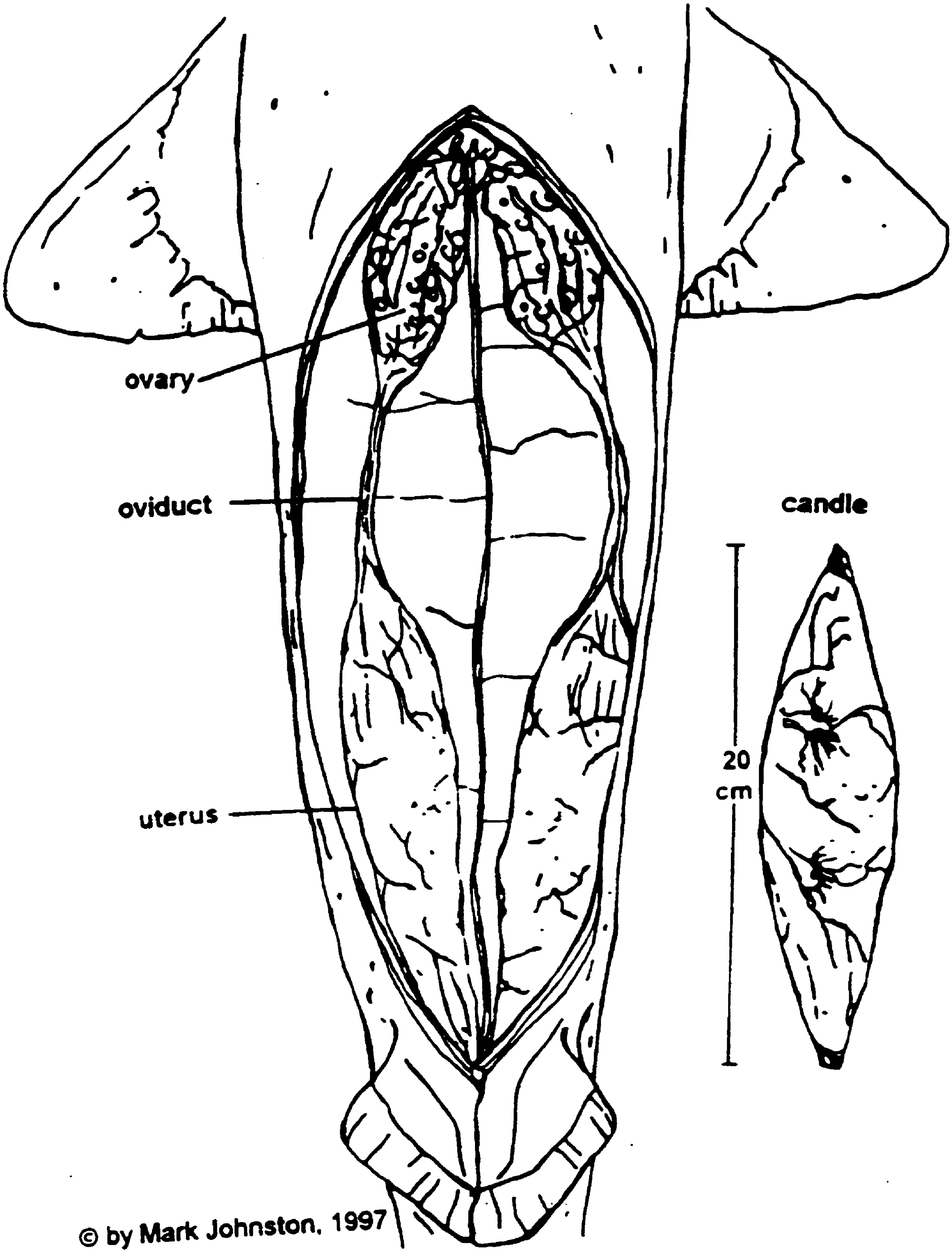


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Figure 11: Stage IV of reproductive tract development in the female spiny dogfish.

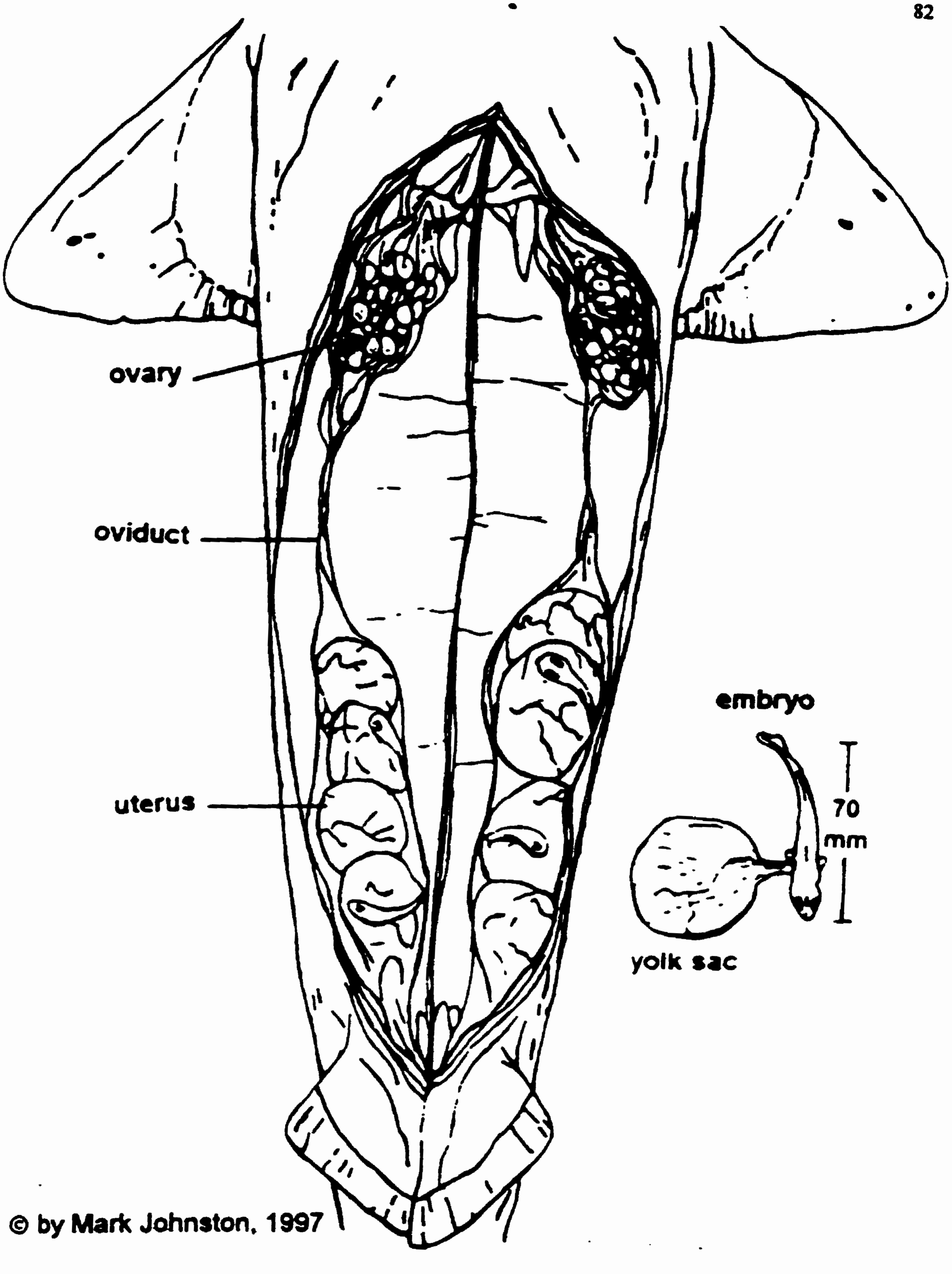

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Figure 12: Stage V of reproductive tract development in the female spiny dogfish.

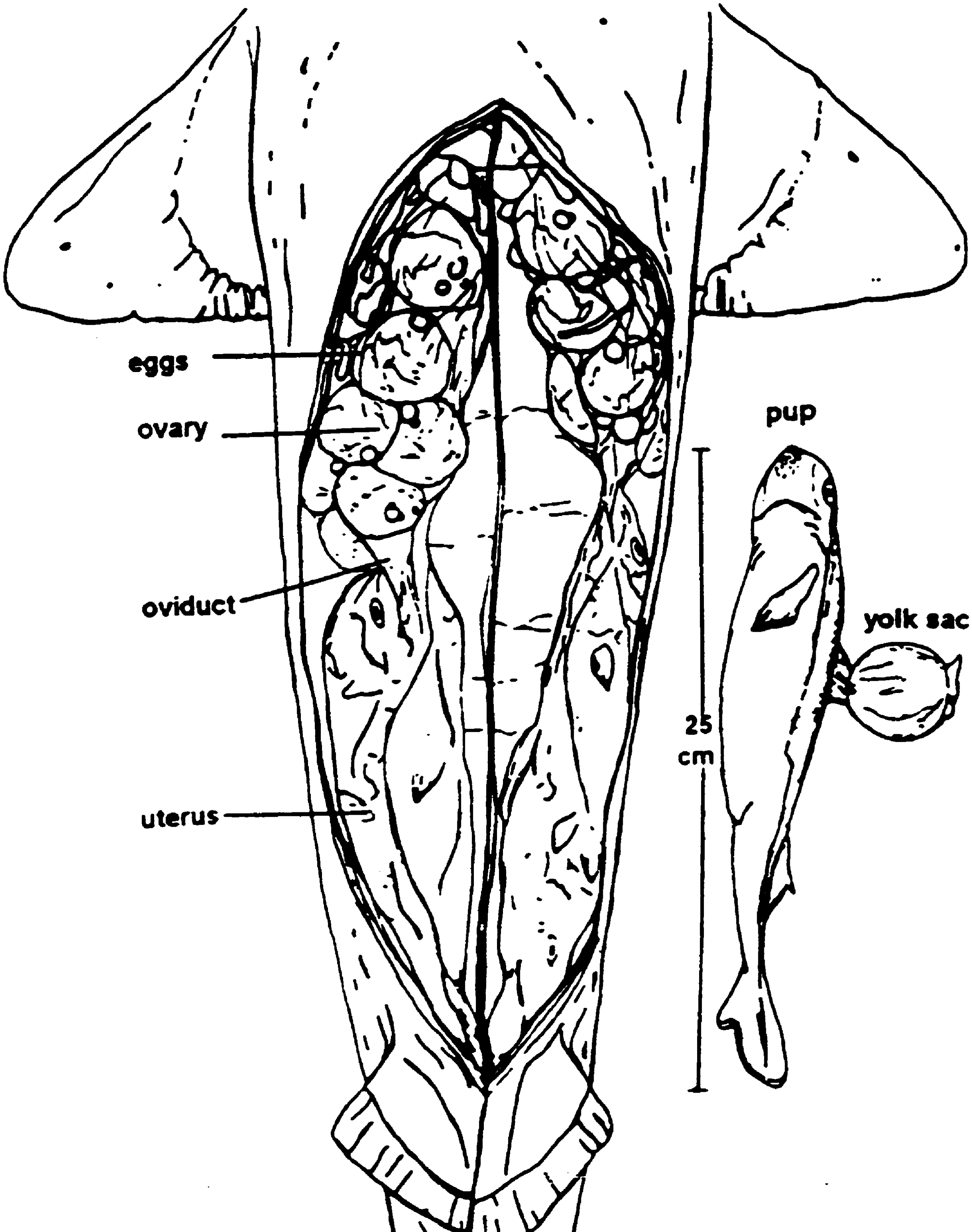
eggs
ovary
oviduct
uterus
pup
yolk sac
25 cm

Figure 13: Stage VI of reproductive tract development in the female spiny dogfish.

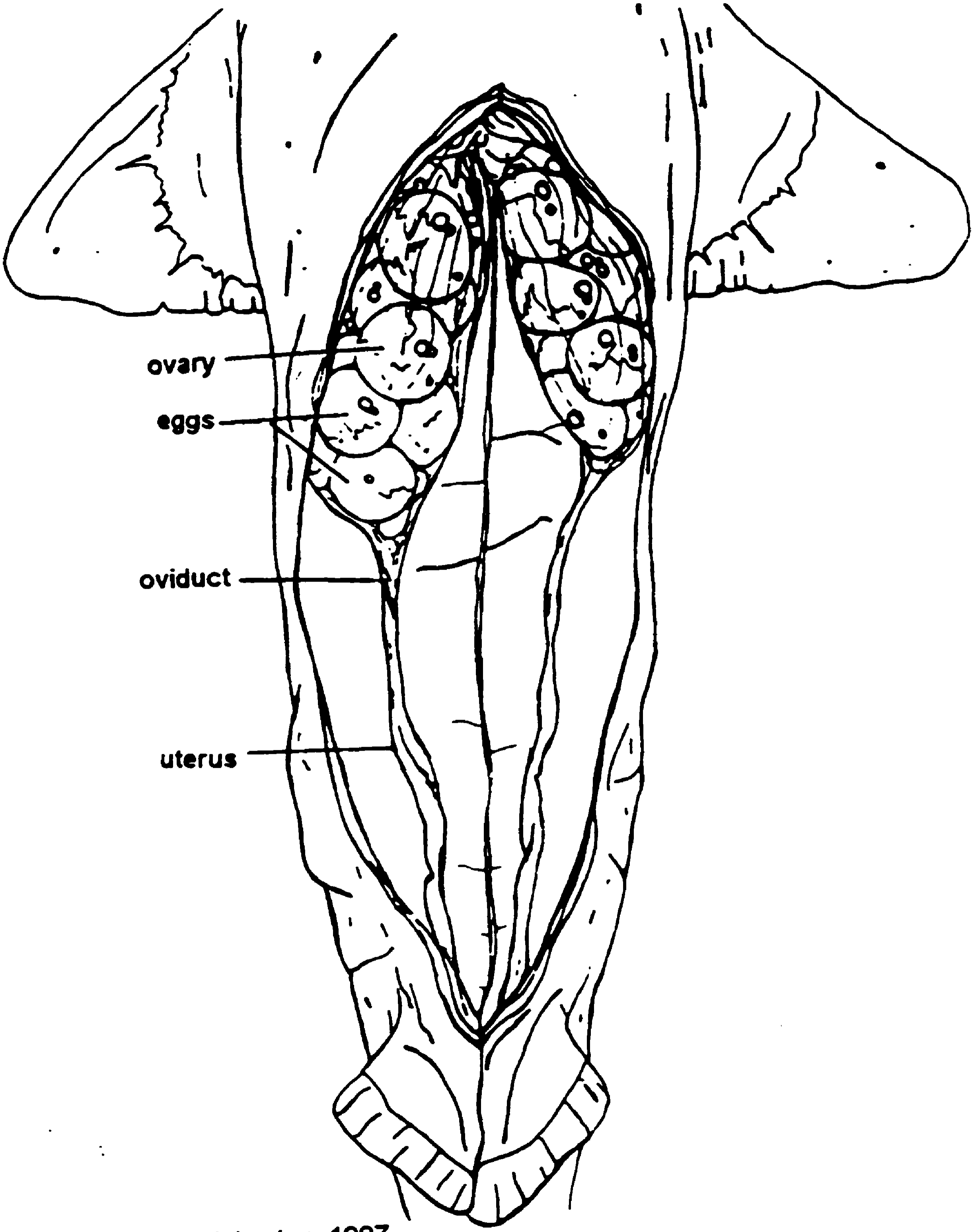

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Figure 14: The N246 DFO Scotian Shelf survey set locations and number of dogfish captured in each tow during July 1996.

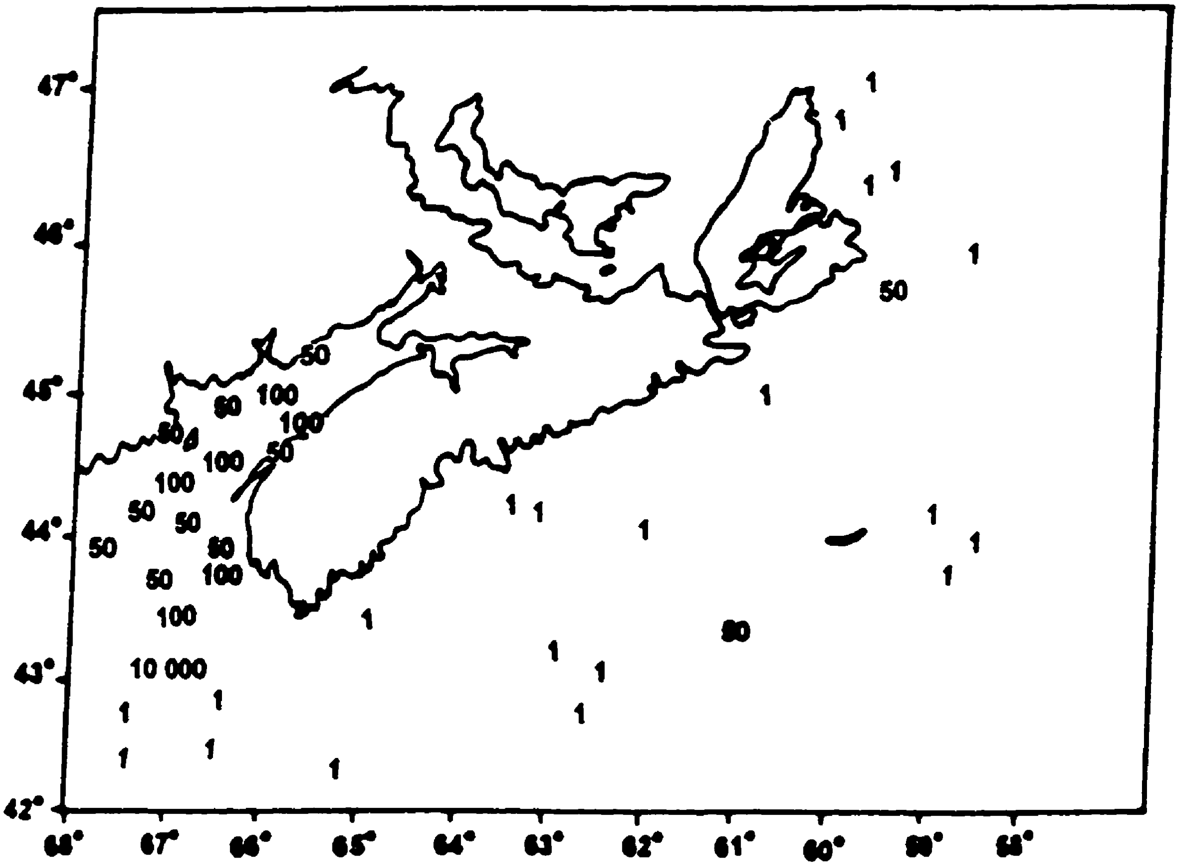

47°
46°
45°
44°
43°
42°
1
1
1
1
1
50
50
1
80
100
100
80
50
100
50
100
50
50
50
80
1
1
1
1
1
1
50
100
100
1
80
10 000
1
1
1
1
1
1
1
68°
67°
66°
65°
64°
63°
62°
61°
60°
59°
58°

Figure 15: The N249 DFO Gulf of St. Lawrence survey set locations and number of spiny dogfish captured in each tow during September 1996.

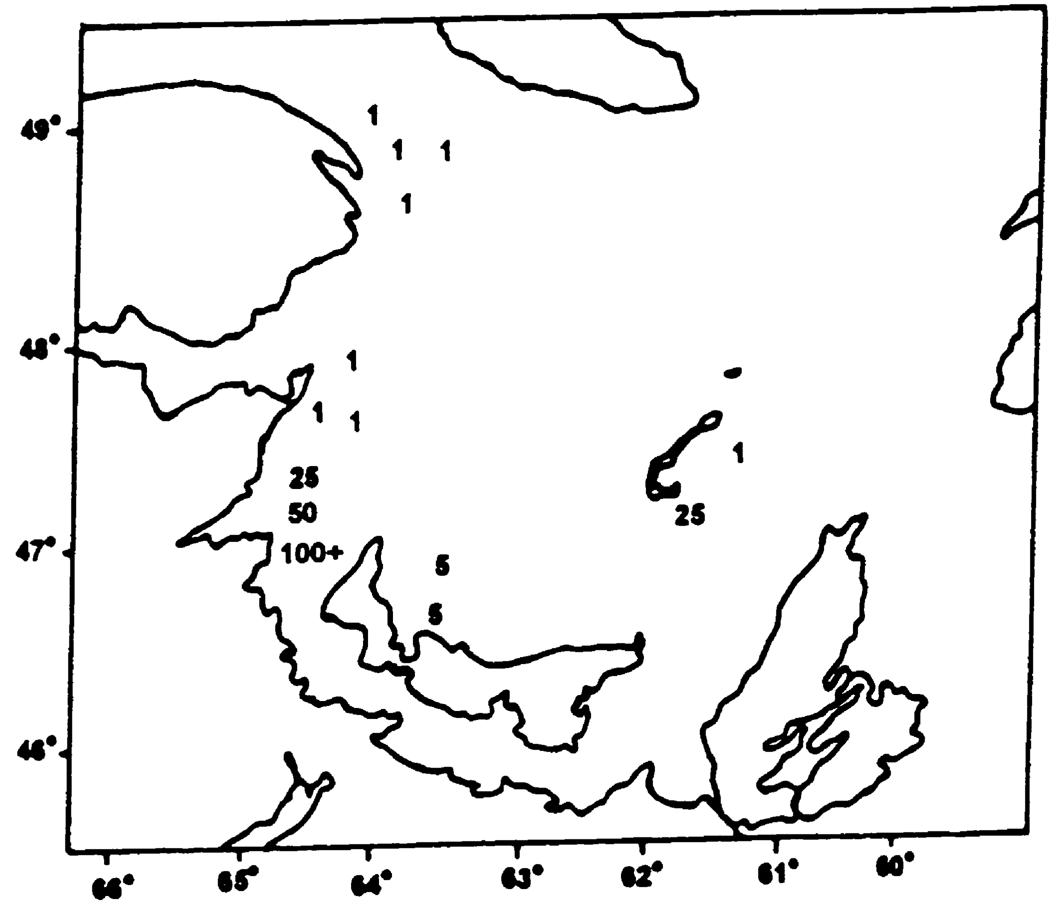

49°
48°
47°
46°
66°
65°
64°
63°
62°
61°
60°
1
1
1
1
1
1
1
1
1
25
50
100+
5
5
25

Figure 16: Total length frequency of female dogfish captured in the Minas Basin, during the N246 DFO survey, and during the N249 DFO survey, summer - fall 1996.

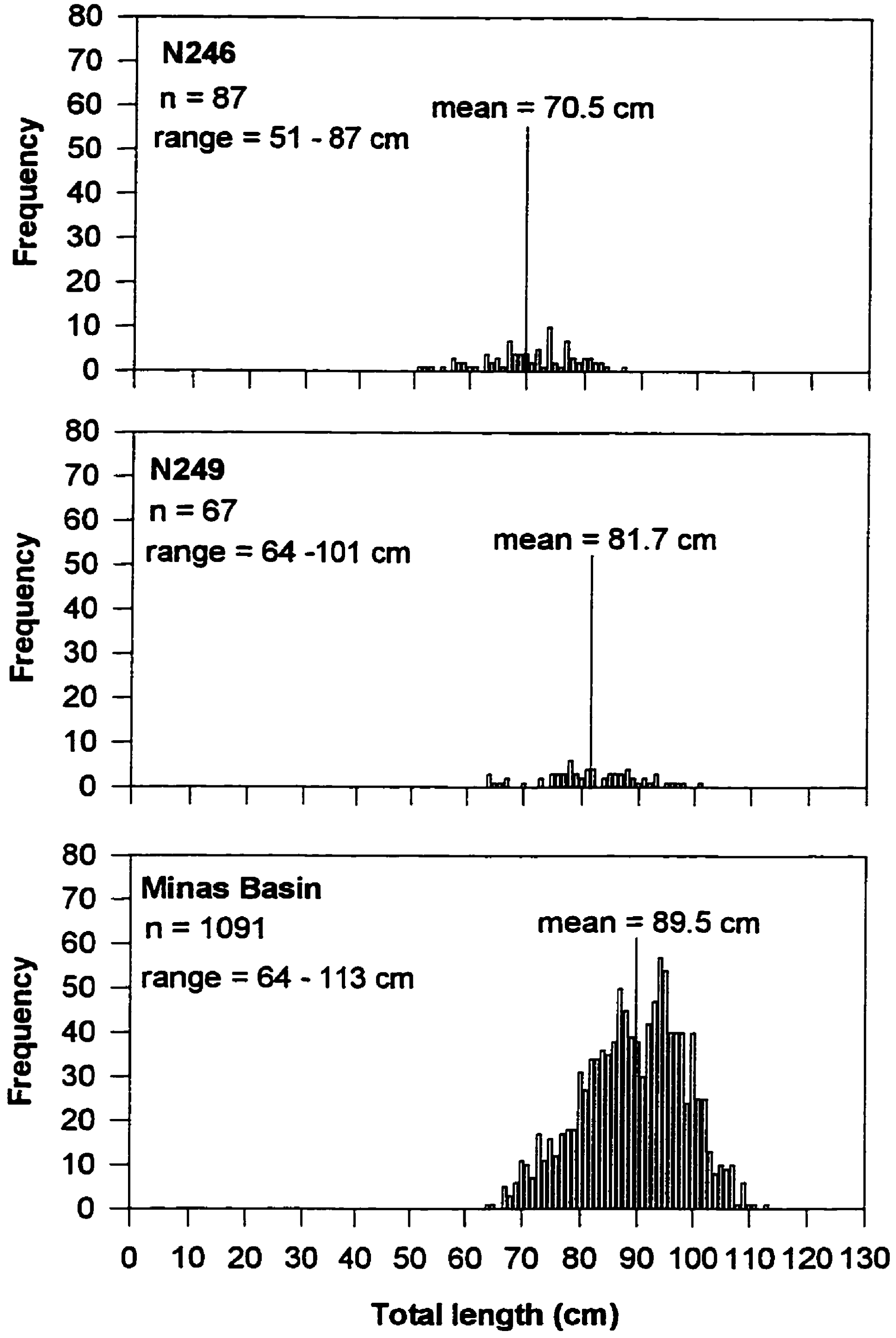

N246
n = 87
range = 51 - 87 cm
mean = 70.5 cm
N249
n = 67
range = 64 -101 cm
mean = 81.7 cm
Minas Basin
n = 1091
range = 64 - 113 cm
mean = 89.5 cm
Frequency
0
10
20
30
40
50
60
70
80
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Total length (cm)

Figure 17: Total length frequency of male dogfish captured in the Minas Basin, during the N246 DFO survey, and during the N249 DFO survey, summer - fall 1996.

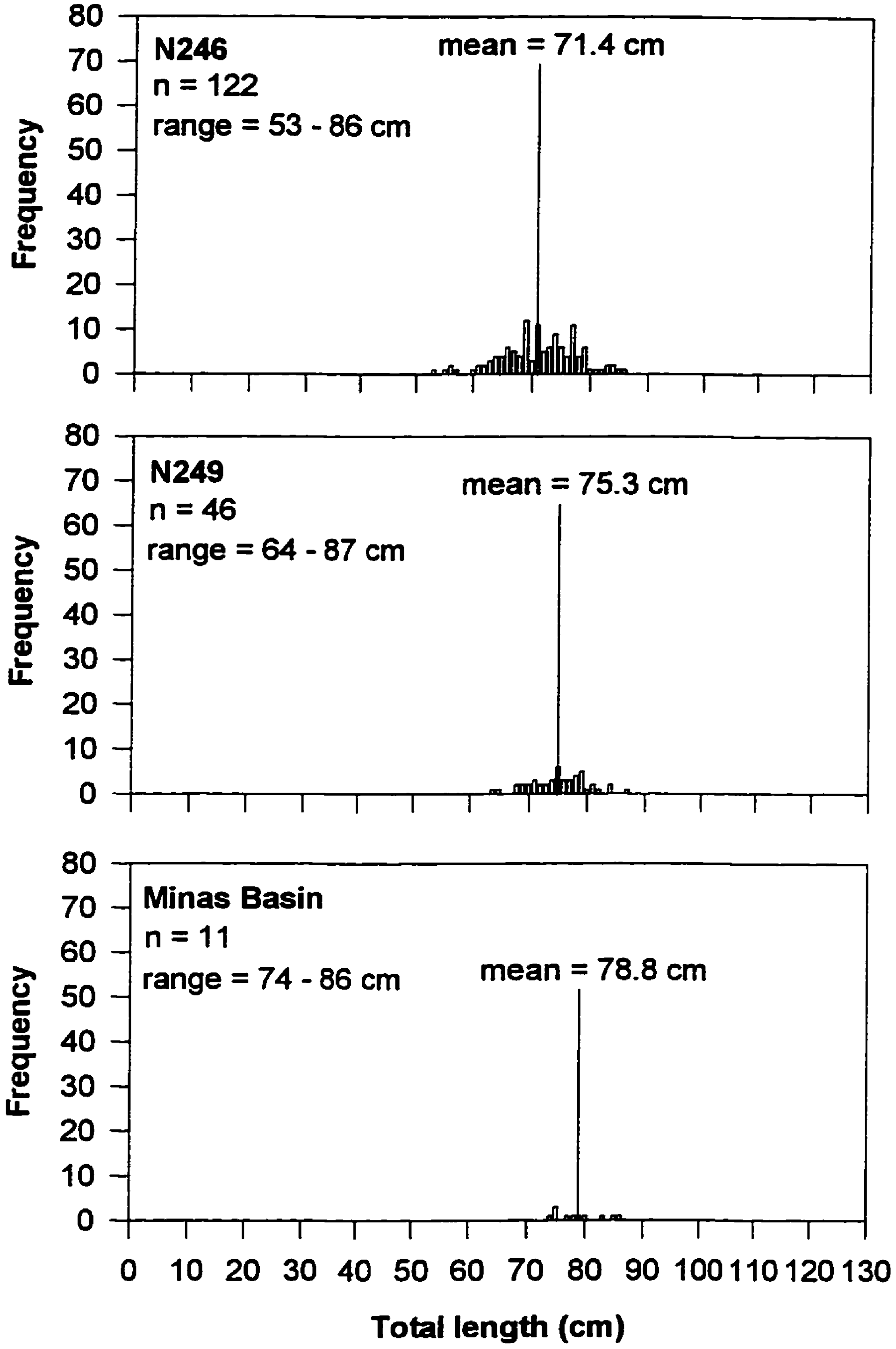

N246
n = 122
range = 53 - 86 cm
mean = 71.4 cm
N249
n = 46
range = 64 - 87 cm
mean = 75.3 cm
Minas Basin
n = 11
range = 74 - 86 cm
mean = 78.8 cm
Frequency
0
10
20
30
40
50
60
70
80
0 10 20 30 40 50 60 70 80 90 100 110 120 130
Total length (cm)

Figure 18: Age frequency of female dogfish captured in the Minas Basin, during the N246 DFO survey, and during the N249 DFO survey, summer - fall 1996.

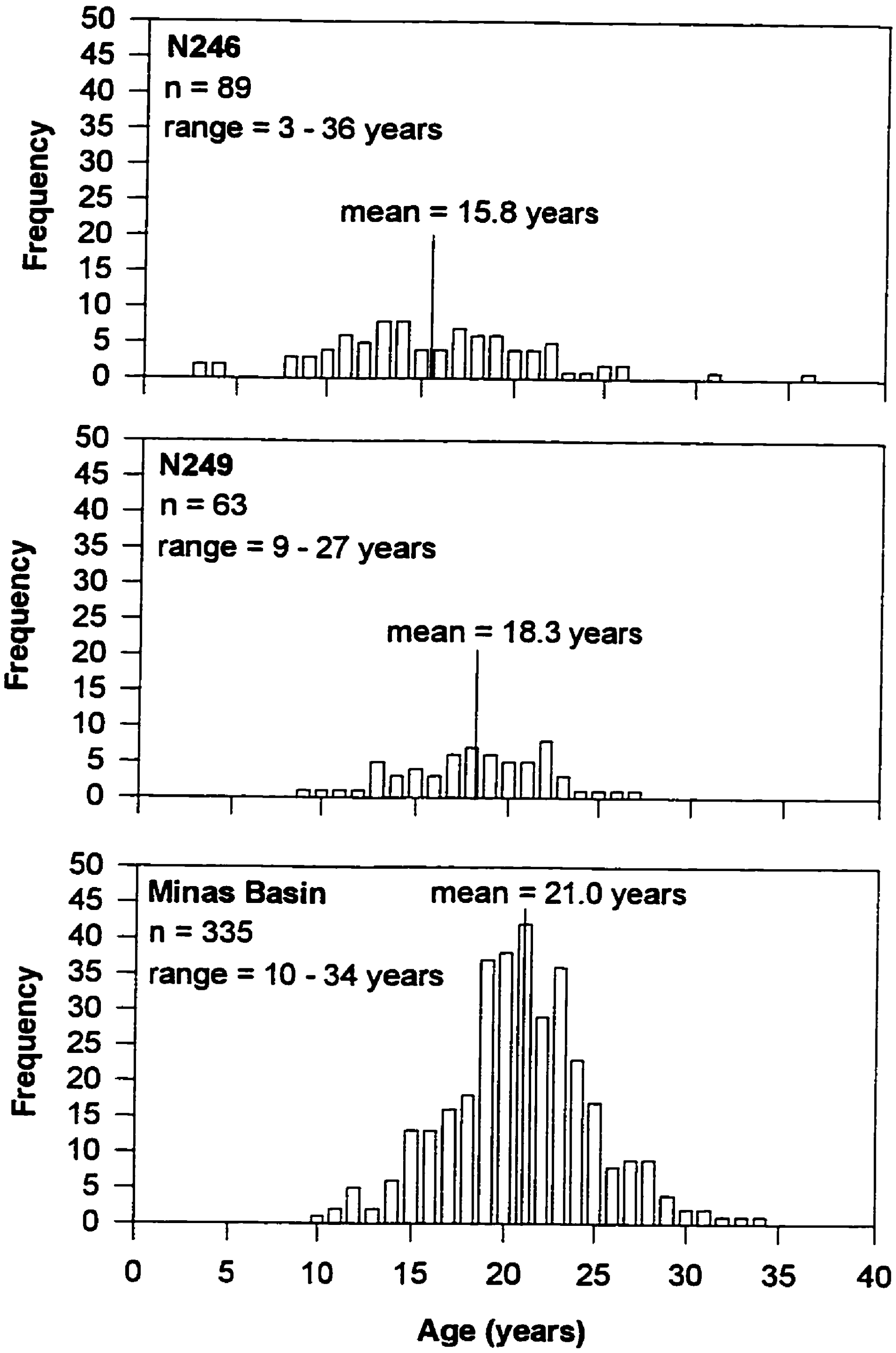

N246
n = 89
range = 3 - 36 years
mean = 15.8 years
N249
n = 63
range = 9 - 27 years
mean = 18.3 years
Minas Basin
n = 335
range = 10 - 34 years
mean = 21.0 years
Frequency
0
5
10
15
20
25
30
35
40
45
50
0
5
10
15
20
25
30
35
40
Age (years)

Figure 19: Age frequency of male dogfish captured in the Minas Basin, during the N246 DFO survey, and during the N249 DFO suvey, summer - fall 1996.

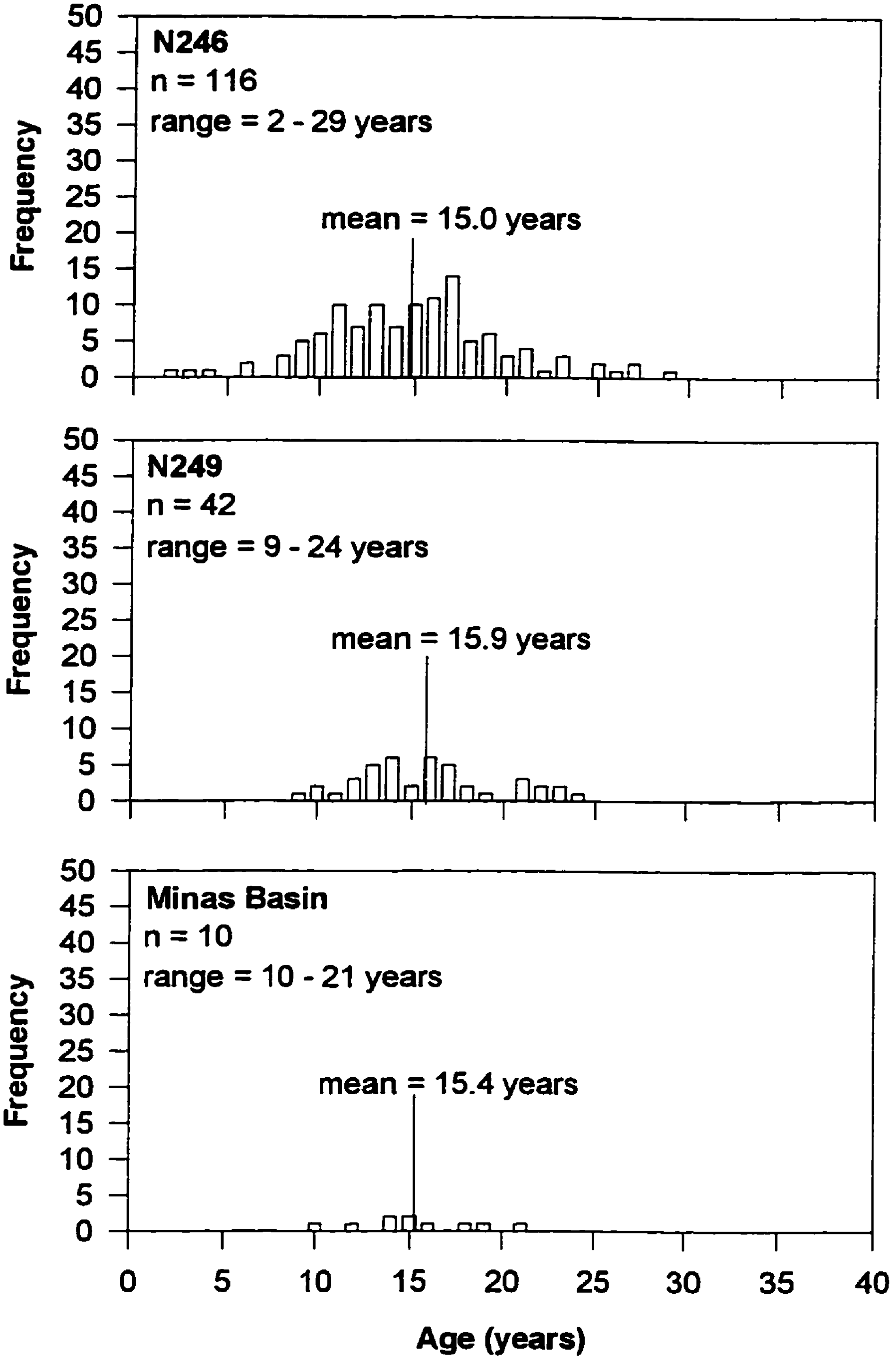

N246
n = 116
range = 2 - 29 years
mean = 15.0 years
N249
n = 42
range = 9 - 24 years
mean = 15.9 years
Minas Basin
n = 10
range = 10 - 21 years
mean = 15.4 years
Frequency
0
5
10
15
20
25
30
35
40
45
50
Age (years)
0
5
10
15
20
25
30
35
40

Figure 20: Weight-length relationship of female spiny dogfish captured in the Minas Basin, during the N246 DFO survey, and during the N249 DFO survey, summer-fall 1996.

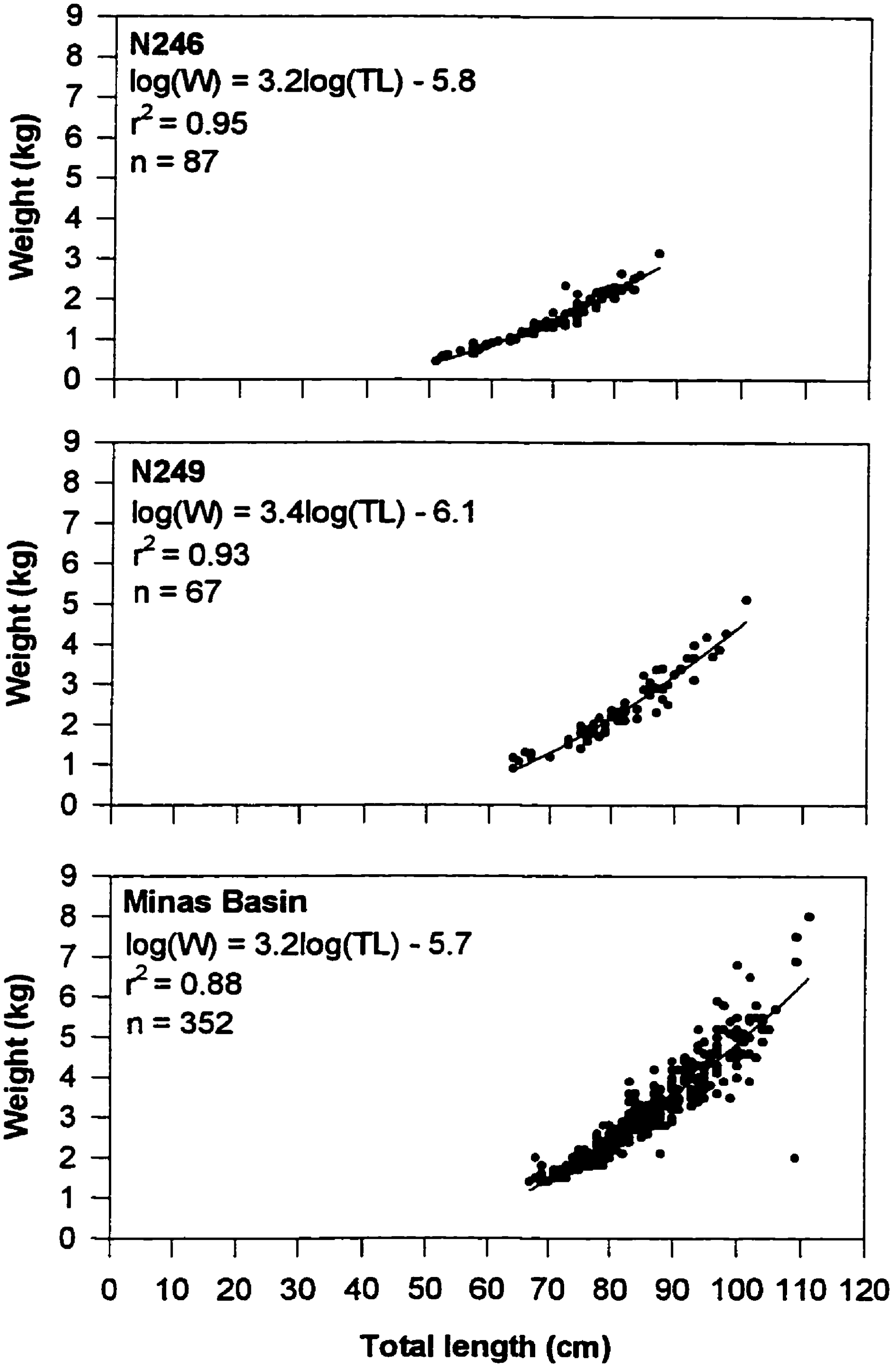

N246
log(W) = 3.2log(TL) - 5.8
r² = 0.95
n = 87
N249
log(W) = 3.4log(TL) - 6.1
r² = 0.93
n = 67
Minas Basin
log(W) = 3.2log(TL) - 5.7
r² = 0.88
n = 352
Weight (kg)
0
1
2
3
4
5
6
7
8
9
Total length (cm)
0
10
20
30
40
50
60
70
80
90
100
110
120

Figure 21: Weight-length relationship of male spiny dogfish captured in the Minas Basin, during the N246 DFO survey, and during the N249 DFO survey, summer- fall 1996.

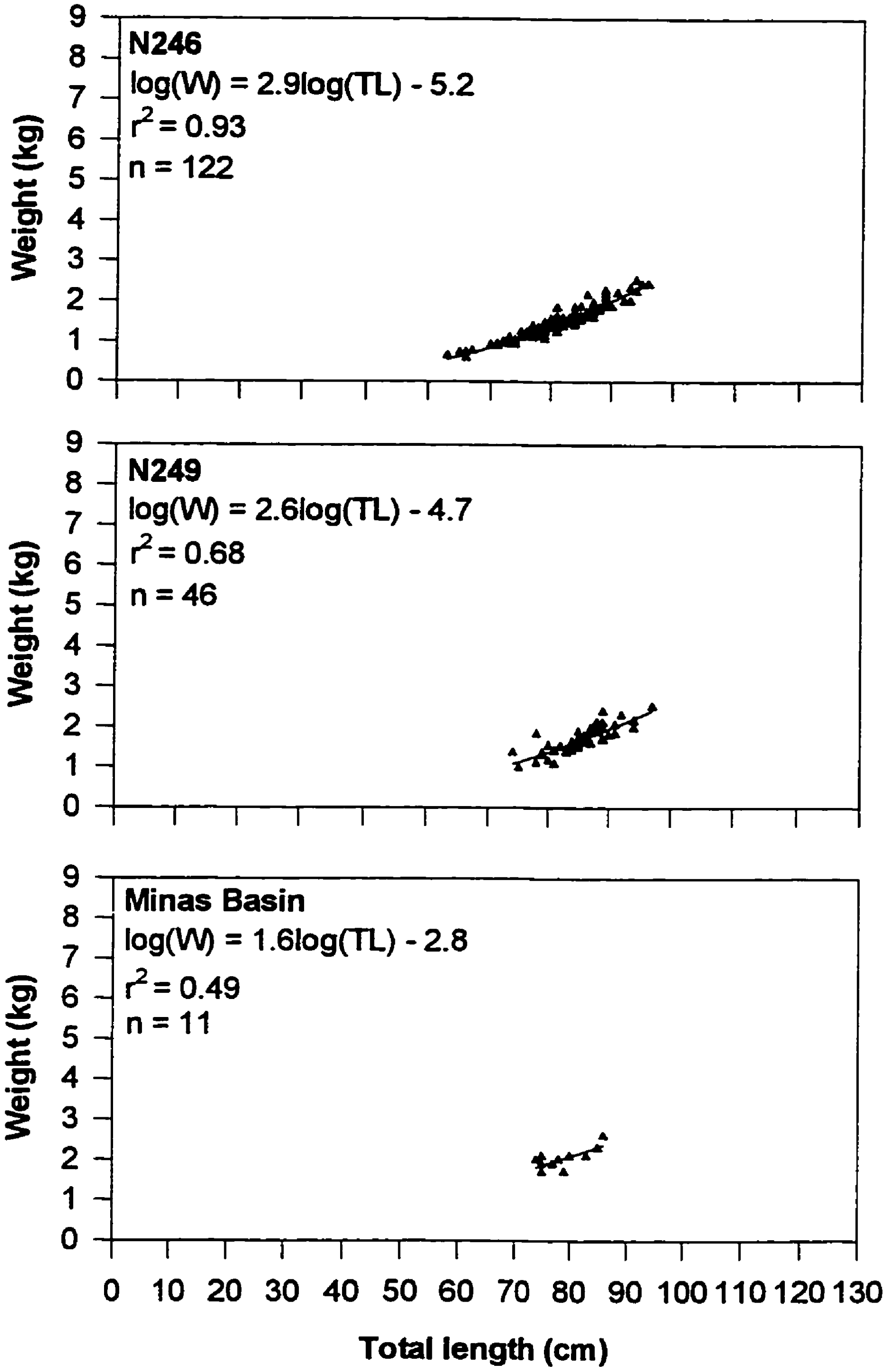

N246
log(W) = 2.9log(TL) - 5.2
r2 = 0.93
n = 122
N249
log(W) = 2.6log(TL) - 4.7
r2 = 0.68
n = 46
Minas Basin
log(W) = 1.6log(TL) - 2.8
r2 = 0.49
n = 11
Weight (kg)
0
1
2
3
4
5
6
7
8
9
Total length (cm)
0
10
20
30
40
50
60
70
80
90
100
110
120
130

Figure 22: Weight-length relationship of male and female spiny dogfish caught at the three study locations in Atlantic Canada during the summer - fall 1996.

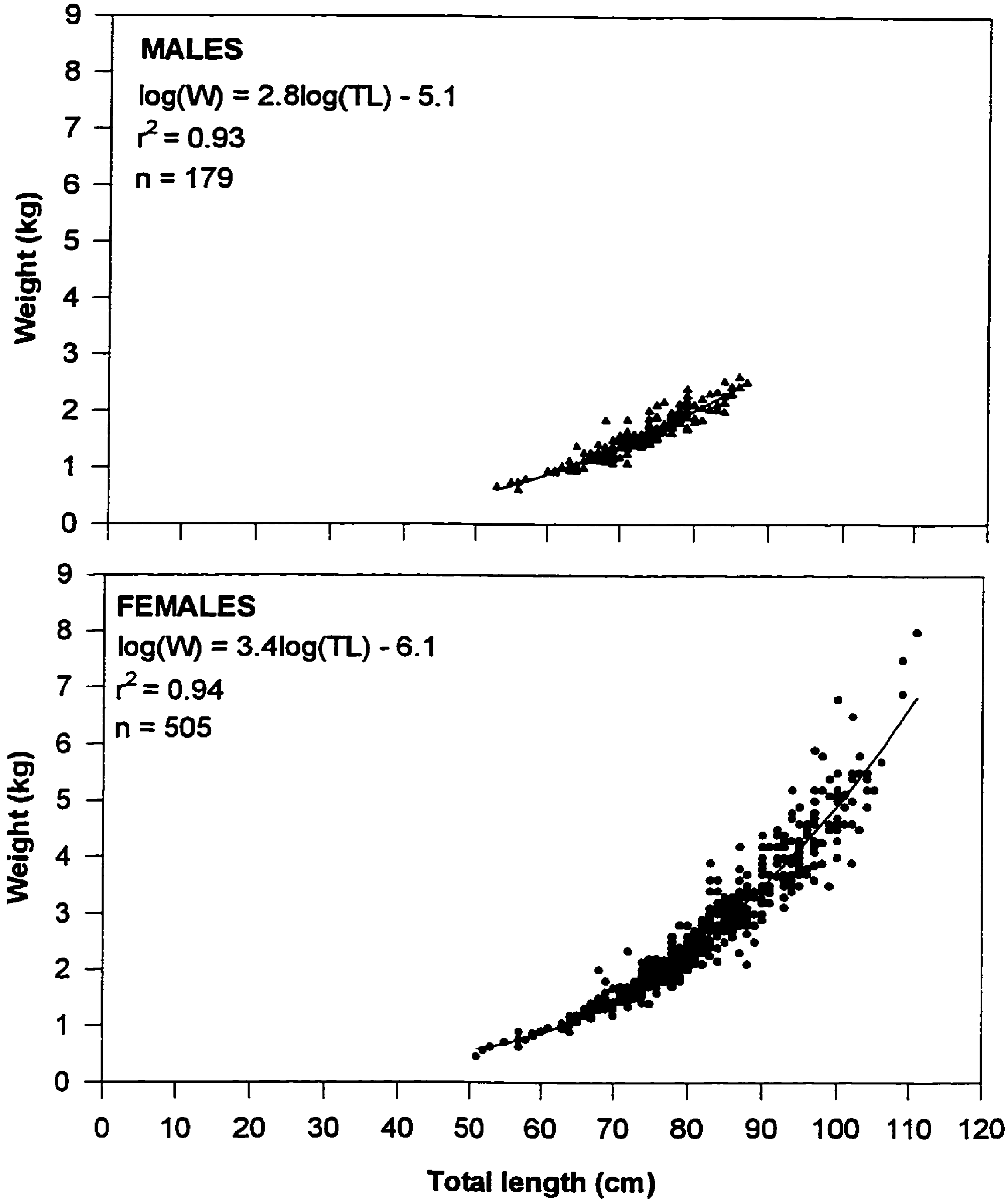

MALES
log(W) = 2.8log(TL) - 5.1
$r^2 = 0.93$
n = 179
FEMALES
log(W) = 3.4log(TL) - 6.1
$r^2 = 0.94$
n = 505
Weight (kg)
Weight (kg)
0
1
2
3
4
5
6
7
8
9
0
10
20
30
40
50
60
70
80
90
100
110
120
Total length (cm)

Figure 23: Spine base diameter (mm) in relation to age (years) of male and female dogfish with wear point diameters ≤1.5 mm to determine the equation for lost annuli due to wear.

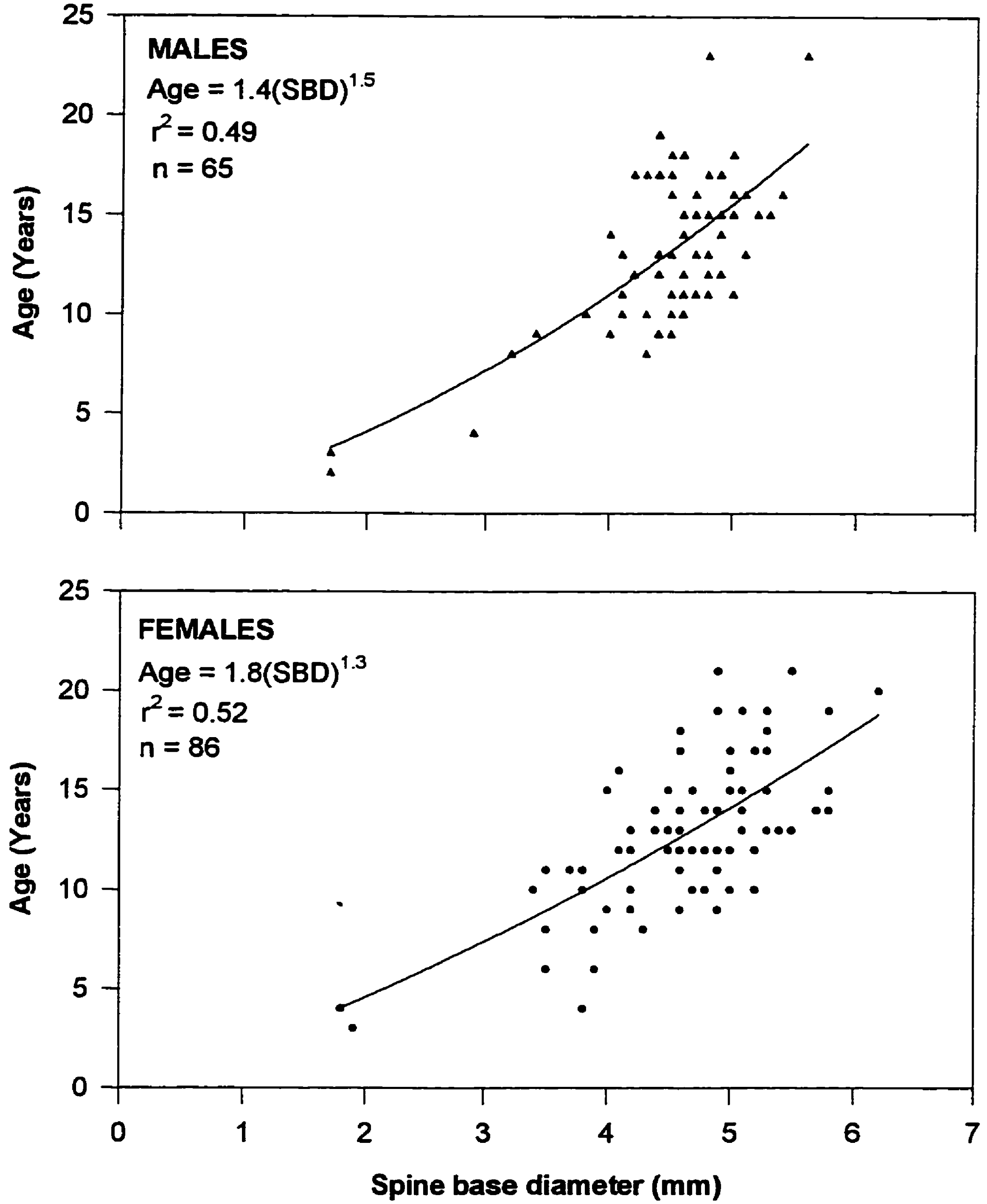

MALES
Age = 1.4(SBD)^1.5
r² = 0.49
n = 65
FEMALES
Age = 1.8(SBD)^1.3
r² = 0.52
n = 86
Age (Years)
0
5
10
15
20
25
0
1
2
3
4
5
6
7
Spine base diameter (mm)

Figure 24: The von Bertalanffy growth equations for female dogfish captured in the Minas Basin, during the N246 DFO survey, and during the N249 DFO survey, summer - fall 1996. Bars represent 1 standard deviation from the mean.

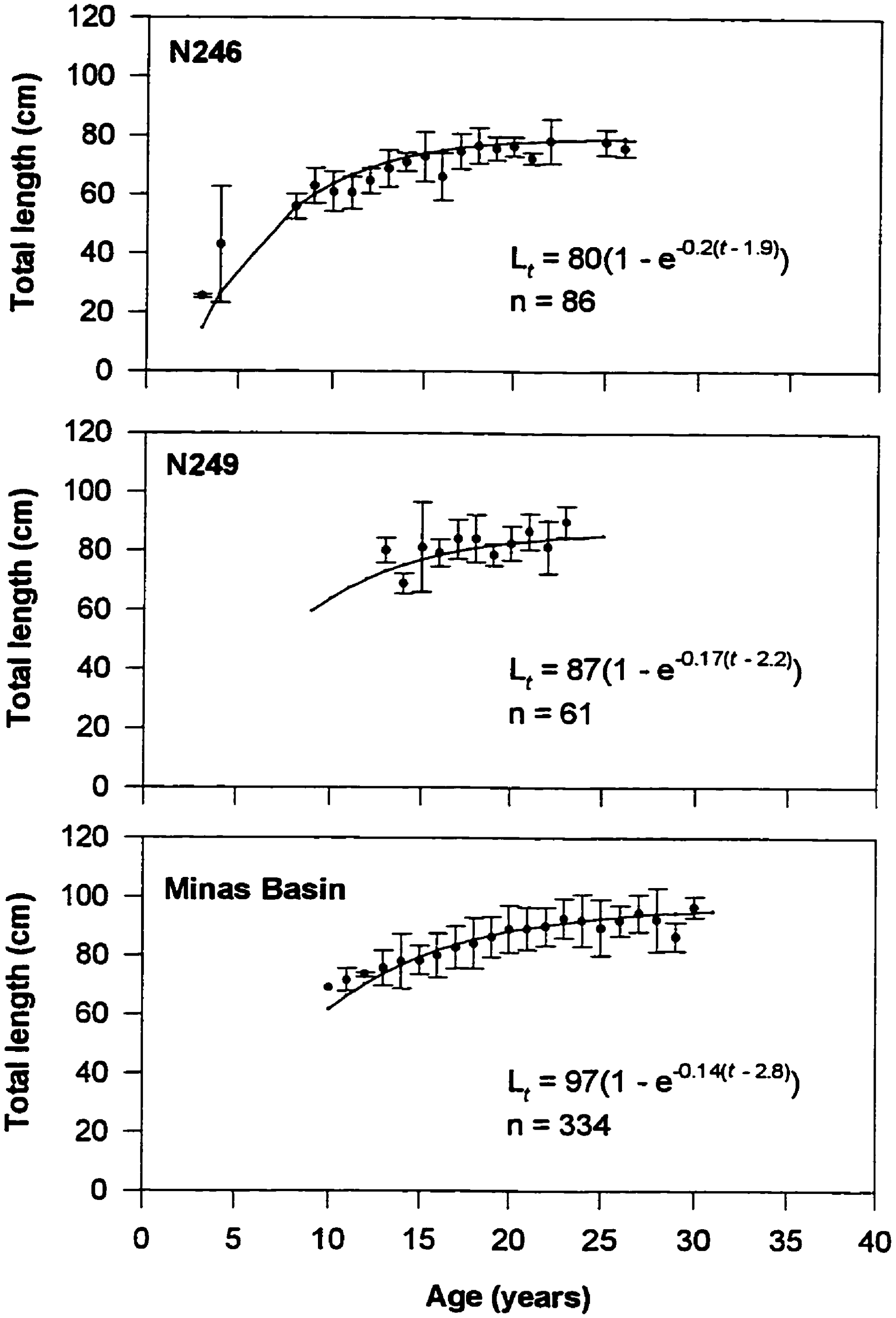

N246
$L_t = 80(1 - e^{-0.2(t - 1.9)})$
n = 86
N249
$L_t = 87(1 - e^{-0.17(t - 2.2)})$
n = 61
Minas Basin
$L_t = 97(1 - e^{-0.14(t - 2.8)})$
n = 334
Total length (cm)
0
20
40
60
80
100
120
Age (years)
0
5
10
15
20
25
30
35
40

Figure 25: The von Bertalanffy growth equations for male dogfish captured in the Minas Basin, during the N246 DFO survey, and during the N249 DFO survey, summer - fall 1996. Bars represent 1 standard deviation from the mean.

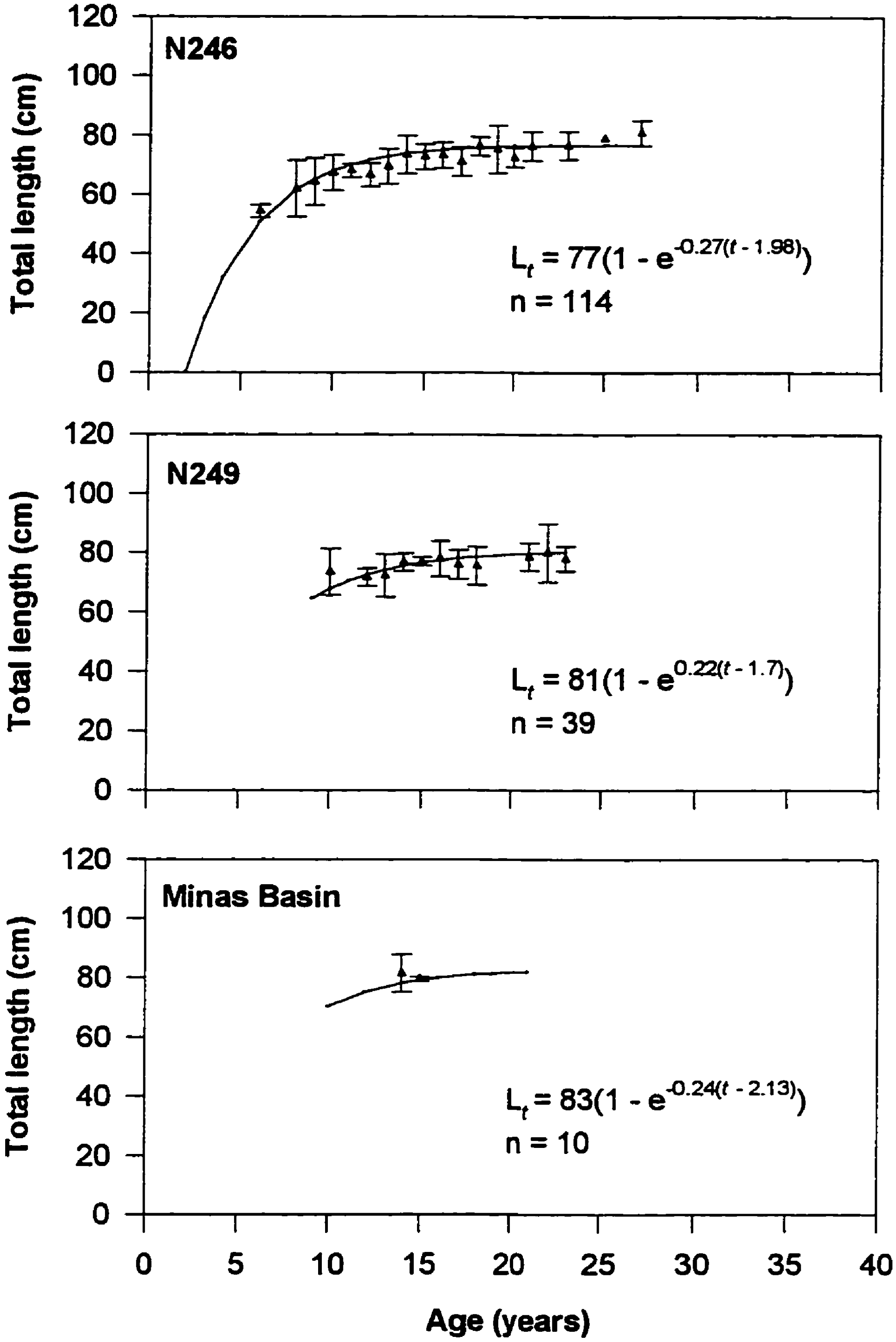

N246
$L_t = 77(1 - e^{-0.27(t - 1.98)})$
n = 114
N249
$L_t = 81(1 - e^{0.22(t - 1.7)})$
n = 39
Minas Basin
$L_t = 83(1 - e^{-0.24(t - 2.13)})$
n = 10
Total length (cm)
0
20
40
60
80
100
120
0
5
10
15
20
25
30
35
40
Age (years)

Figure 26: The von Bertalanffy growth equations for male and female dogfish captured at the three study locations in Atlantic Canada during the summer - fall 1996. Bars represent 1 standard deviation from the mean.

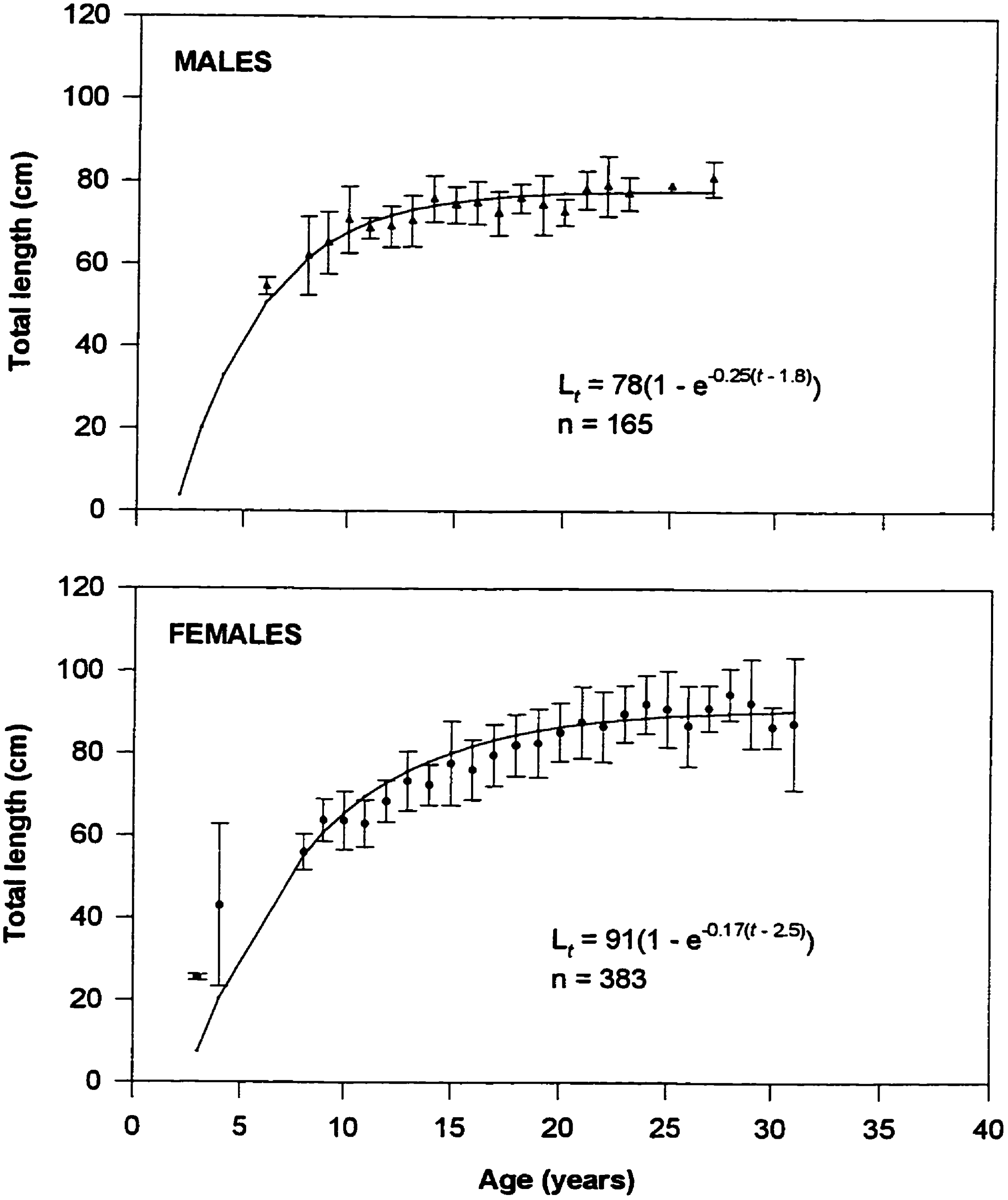

MALES
Total length (cm)
0
20
40
60
80
100
120
$L_t = 78(1 - e^{-0.25(t - 1.8)})$
n = 165
FEMALES
Total length (cm)
0
20
40
60
80
100
120
$L_t = 91(1 - e^{-0.17(t - 2.5)})$
n = 383
0
5
10
15
20
25
30
35
40
Age (years)

Figure 27: Percent maturity of female dogfish captured in the Minas Basin, during the N246 DFO survey, and during the N249 DFO survey, summer - fall 1996.

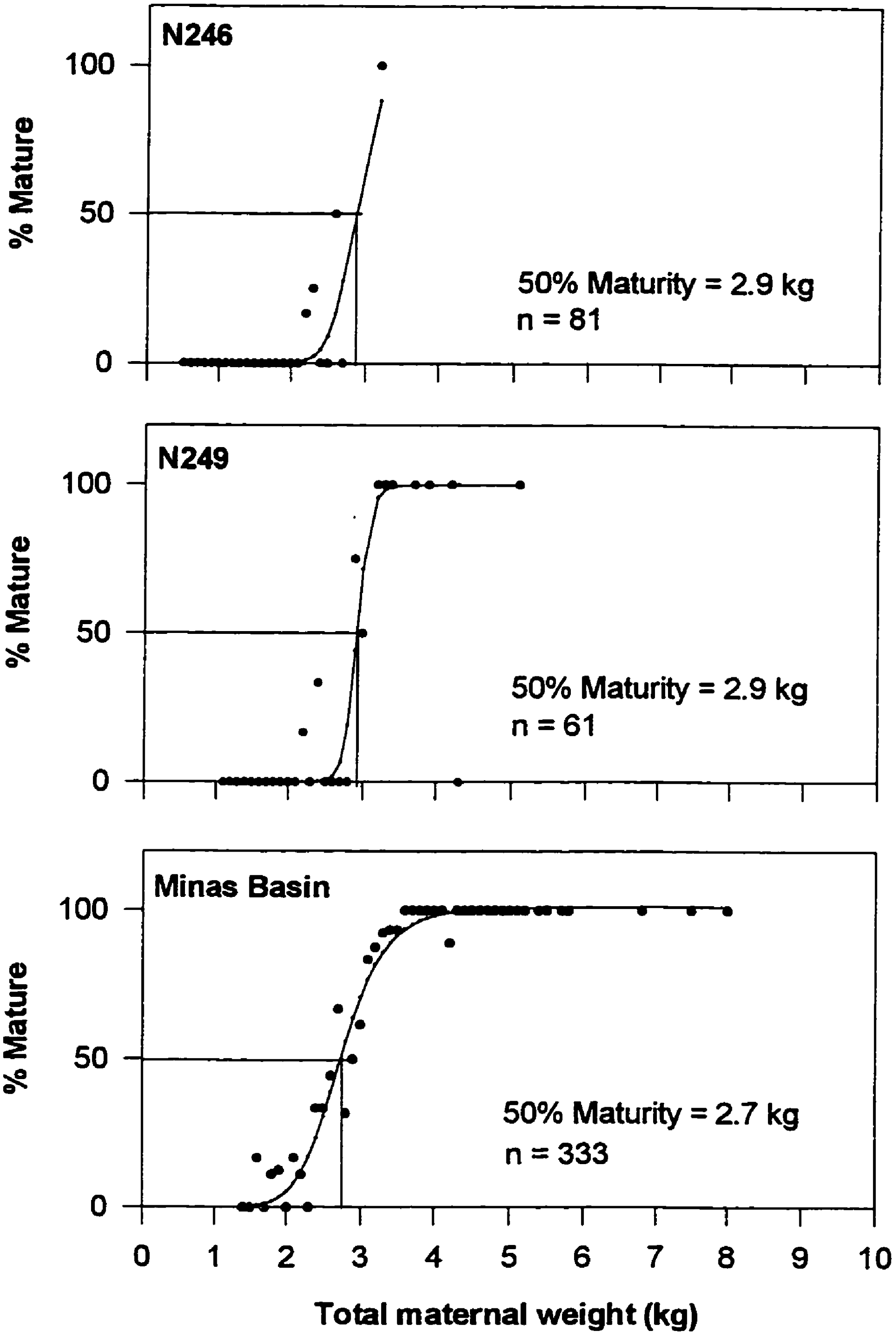

N246
% Mature
100
50
0
50% Maturity = 2.9 kg
n = 81
N249
% Mature
100
50
0
50% Maturity = 2.9 kg
n = 61
Minas Basin
% Mature
100
50
0
50% Maturity = 2.7 kg
n = 333
0
1
2
3
4
5
6
7
8
9
10
Total maternal weight (kg)

Figure 28: Percent maturity of female dogfish captured at the three study locations in Atlantic Canada during the summer - fall 1996.

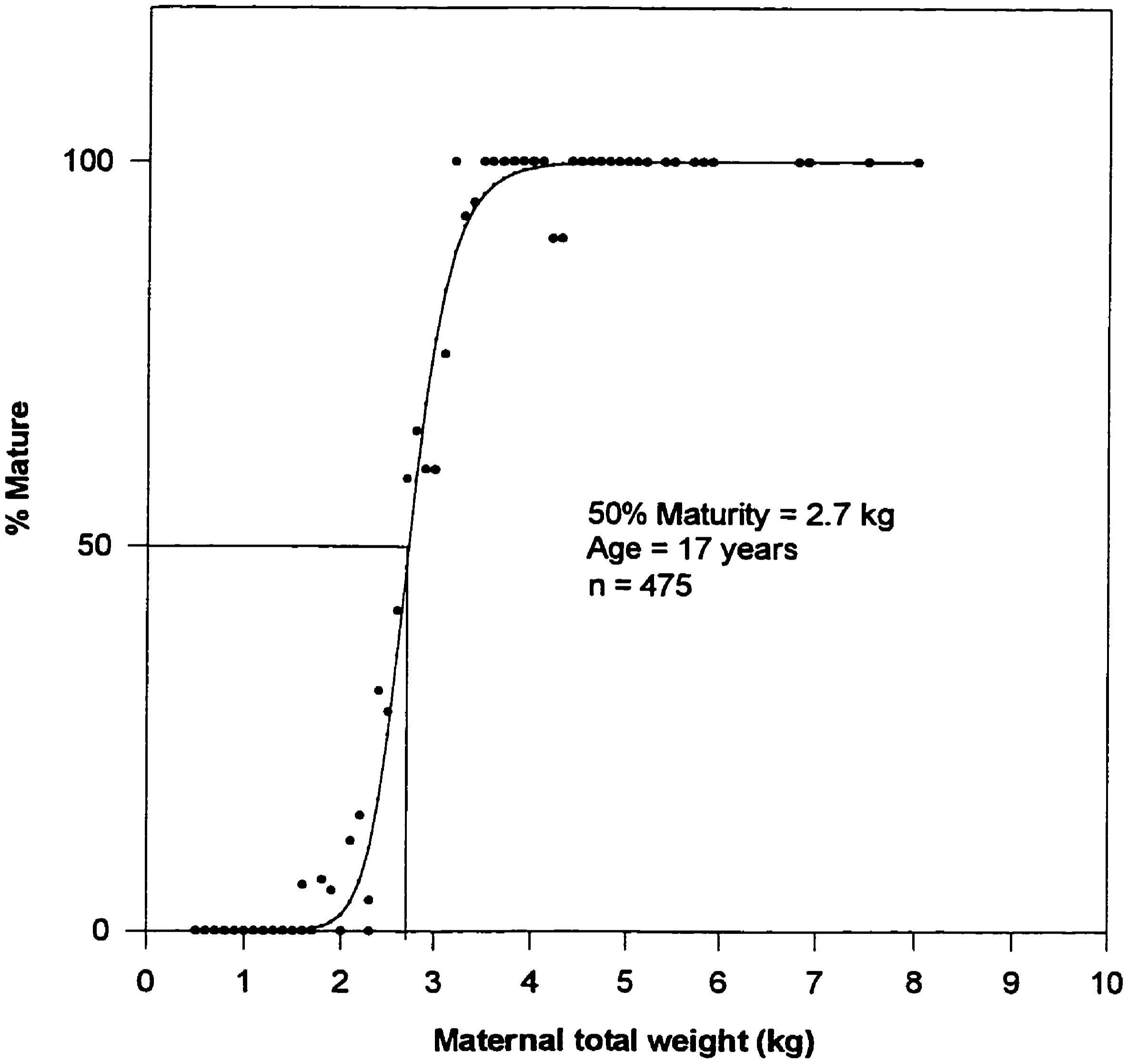

% Mature
100
50
0
50% Maturity = 2.7 kg
Age = 17 years
n = 475
0
1
2
3
4
5
6
7
8
9
10
Maternal total weight (kg)

Figure 29: Number of progeny (NP) in relation to total maternal weight(TMW)(kg) for fecundity of the female dogfish captured in the Minas Basin, on the N246 DFO survey, and on the N249 DFO survey during the summer - fall 1996.

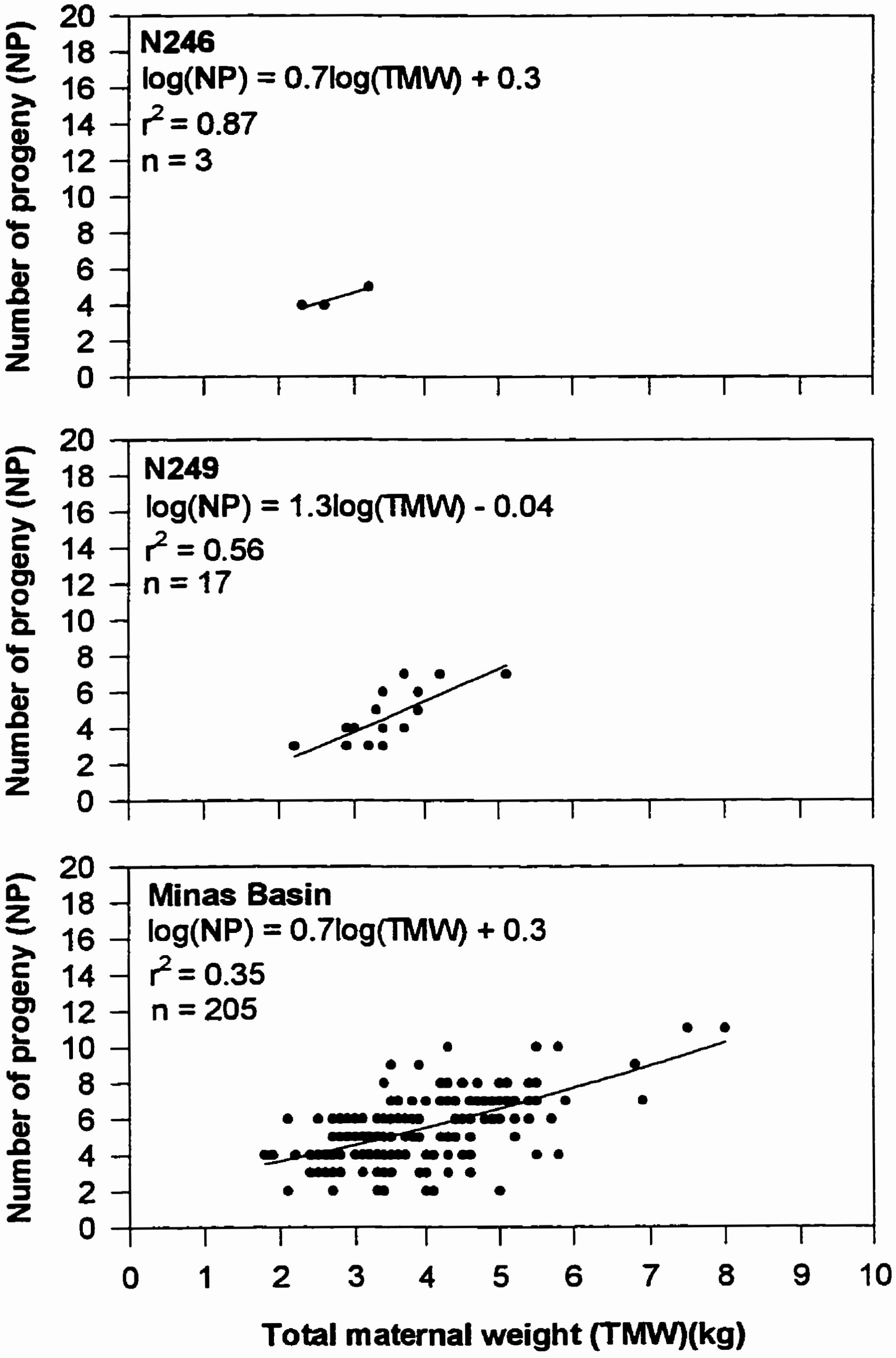

Number of progeny (NP)
20
18
16
14
12
10
8
6
4
2
0
N246
log(NP) = 0.7log(TMW) + 0.3
r^2 = 0.87
n = 3
N249
log(NP) = 1.3log(TMW) - 0.04
r^2 = 0.56
n = 17
Minas Basin
log(NP) = 0.7log(TMW) + 0.3
r^2 = 0.35
n = 205
0
1
2
3
4
5
6
7
8
9
10
Total maternal weight (TMW)(kg)

Figure 30: Number of progeny (NP) in relation to the total maternal weight (TMW)(kg) for fecundity of female dogfish captured at the three study locations in Atlantic Canada during the summer - fall 1996.

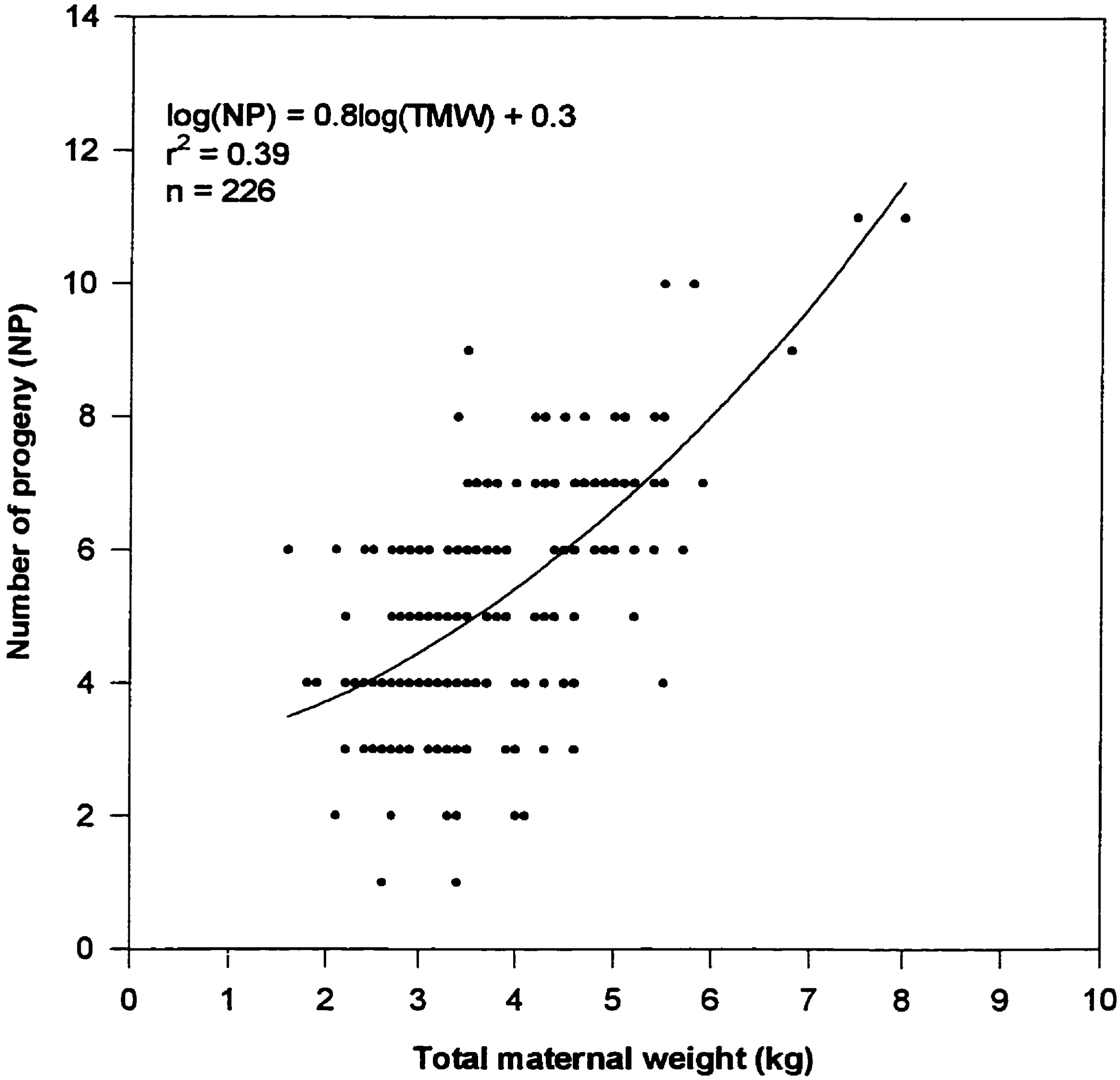
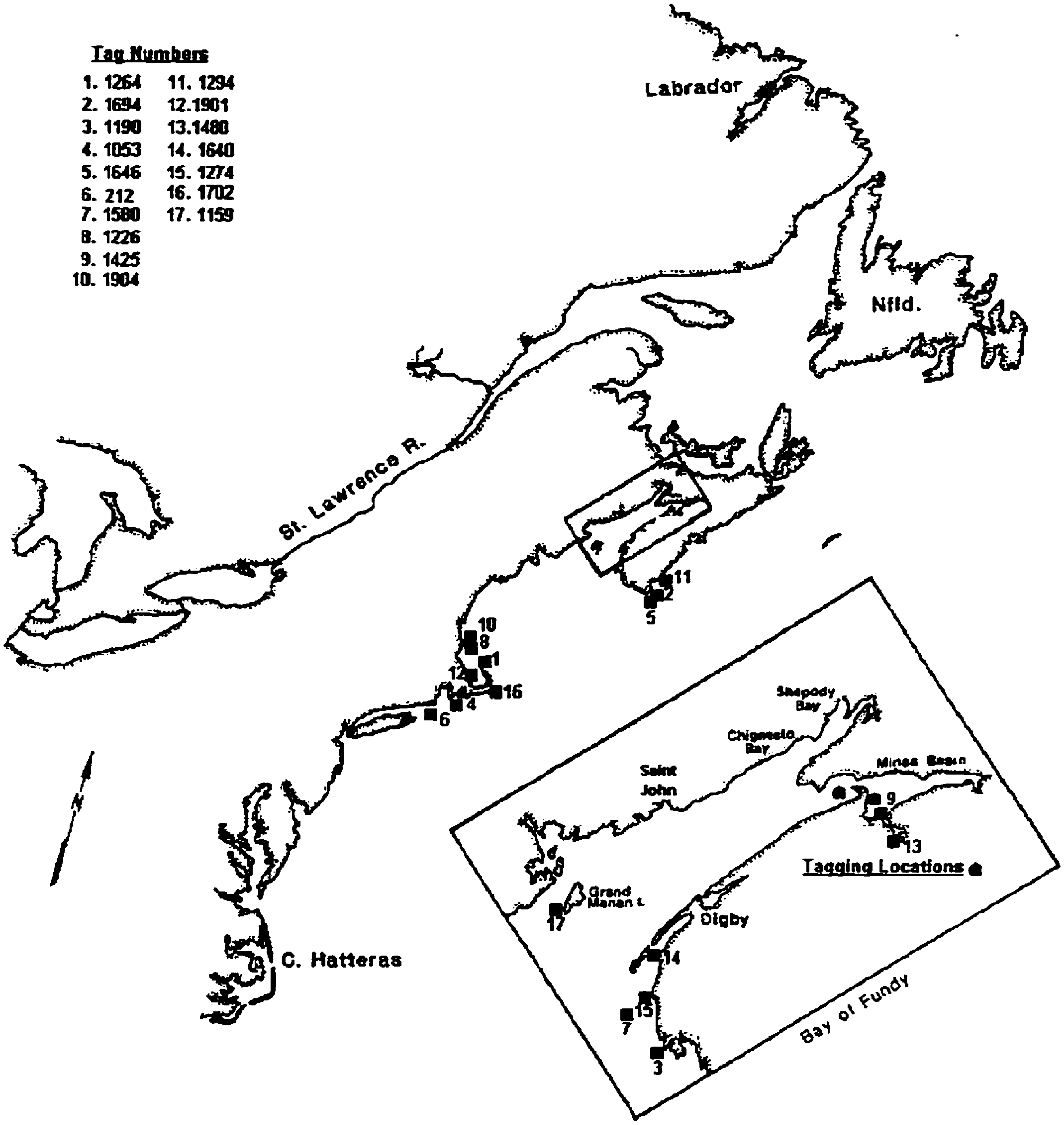

log(NP) = 0.8log(TMW) + 0.3
r2 = 0.39
n = 226
Number of progeny (NP)
0
2
4
6
8
10
12
14
Total maternal weight (kg)
0
1
2
3
4
5
6
7
8
9
10

Figure 31: Tag return locations for dogfish marked in the Minas Basin during the summer of 1996.


Tag Numbers
1. 1264
2. 1694
3. 1190
4. 1053
5. 1646
6. 212
7. 1580
8. 1226
9. 1425
10. 1904
11. 1294
12. 1901
13. 1480
14. 1640
15. 1274
16. 1702
17. 1159
Labrador
Nfld.
St. Lawrence R.
C. Hatteras
N
Shepody Bay
Chignecto Bay
Saint John
Minas Basin
Tagging Locations ●
Grand Manan I.
Digby
Bay of Fundy

Appendices

Appendix 1: Raw data for female spiny dogfish captured in the Minas Basin from July 7 - October 10, 1996. TL = Total length; FL = Fork length.

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age	Reproductive stage	Egg number	Embryo number
1b	100	90	4.3	10	22	3	-	8
2b	103	91	4.5	9	22	3	-	11
3b	84	85	3.6	10	25	5	7	6
5b	95	86	4.0	16	19	5	7	6
6b	94	86	3.5	13	24	5	4	1
7b	97	85	4.1	9	21	5	7	5
8b	102	89	3.9	10	24	5	6	2
9b	91	81	3.5	13	20	-	-	-
10b	85	75	2.5	14	-	1	-	-
11b	77	67	1.8	15	17	1	-	-
12b	97	86	4.2	14	23	5	7	5
13b	84	74	3.0	18	27	3	-	5
14b	102	92	5.0	8	22	3	-	2
15b	100	89	5.0	12	21	-	-	-
16b	97	86	3.6	10	21	3	-	5
17b	96	85	3.8	14	22	-	-	-
18b	94	84	3.9	18	27	3	-	6
19b	94	83	3.7	17	24	5	4	5
20b	88	77	3.3	15	21	3	-	4
21b	98	83	3.9	7	21	3	-	3
22b	92	80	3.9	13	20	5	6	6
23b	91	80	3.4	12	19	5	5	6
24b	87	76	3.2	11	16	2	5	-
25b	93	82	3.7	18	24	3	-	5

Appendix 1: continued

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age	Reproductive stage	Egg number	Embryo number
26b	99	87	4.6	11	21	3	-	5
27b	94	82	3.4	13	23	3	-	3
28b	94	83	4.0	14	24	3	-	4
29b	86	76	2.7	17	22	3	-	2
30b	89	79	3.3	16	23	3	-	2
31b	93	81	3.7	16	20	3	-	4
32b	105	94	5.2			3	-	6
33b	90	79	3.0	6	18	5	5	5
34b	95	83	3.7	12	18	3	-	4
35b	98	88	5.5	10		5	7	7
36b	95	85	4.5	14	23	3	-	6
37b	79	68	1.8	26	29	1	-	-
38b	73	64	1.7	17	17	1	-	-
39b	89	74	2.8	17	21	2	5	-
40b	86	75	3.1	30	33	3	-	2
41b	94	84	3.5	14	22	-	-	-
42b	95	83	4.0	12	22	3	-	3
43b	97	85	4.6	18	24	5	7	7
44b	88	78	3.4	15	21	3	-	4
45b	86	76	3.2	18	23	3	-	5
46b	102	90	4.6	19	29	3	-	6
47b	98	87	3.9	15	23	3	-	5
48b	100	90	5.0	6	23	-	-	-
49b	89	79	3.4	17	25	5	6	3
50b	97	86	4.3	21	27	2	3	-

Appendix 1: continued

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age	Reproductive stage	Egg number	Embryo number
51b	93	81	4.3	13	24	-	-	-
52b	102	90	4.7	12	21	5	8	3
53b	104	91	5.2	10	23	-	-	-
54b	100	87	4.4	8	21	-	-	-
55b	83	73	2.5	18	20	-	-	-
56b	109	97	5.8	13	19	3	-	4
57b	93	82	4.0	20	28	5	7	3
58b	85	74	2.7	21	26	3	-	3
59b	83	72	2.5	28	30	1	-	-
60b	87	77	2.9	19	24	1	-	-
61b	96	85	4.3			3	-	5
62b	81	72	2.6	12	16	-	-	-
63b	99	88	4.5	25	31	3	-	4
64b	103	91	5.2	11	24	3	-	4
65b	80	70	2.5	22	25	2	6	-
66b	90	79	3.4	15	20	5	5	4
67b	99	87	4.5	11	26	3	-	4
68b	83	73	2.4	19	23	3	-	8
69b	83	73	2.8	29	34	3	-	8
70b	103	91	5.8	8	19	3	-	8
71b	100	87	4.7	16	28	3	-	8
72b	92	81	3.8	10	23	5	7	4
73b	101	87	4.6	14	24	3	-	4
74b	97	87	4.1	20	28	3	-	4
75b	94	83	4.3	17	24	5	7	7

Appendix 1: continued

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age	Reproductive stage	Egg number	Embryo number
76b	88	77	3.1	18	24	3	-	3
77b	84	75	2.7	14	19	3	-	4
78b	95	84	4.2	15	23	-	-	-
79b	100	89	4.0	11	22	3	-	1
80b	97	86	5.1	16	21	-	-	-
81b	90	80	3.4	23	27	3	-	5
82b	83	73	2.7	15	19	2	2	-
83b	95	83	3.7	17	22	6	5	-
84b	85	74	3.2	15	24	5	5	5
85b	81	72	2.6	16	20	1	-	4
86b	80	72	2.8	16	22	2	5	-
87b	90	80	3.7	20	28	3	-	4
88b	77	68	1.9	19	19	3	-	4
89b	71	62	1.5	15	15	1	-	-
90b	90	80	3.4			5	4	4
91b	79	69	2.2	22	25	2	4	-
92b	86	76	2.7	26	28	2	6	-
93b	87	76	3.6	23	27	5	7	5
94b	86	77	3.3			5	5	4
95b	95	85	4.6	16	27	5	7	5
96b	84	75	2.8	21	26	2	6	11
97b	93	83	3.5	20	25	5	5	2
98b	94	84	3.9			5	7	3
99b	78	68	1.8	18	21	3	-	4
100b	81	70	2.2	17	22	1	-	-

Appendix 1: continued

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age	Reproductive stage	Egg number	Embryo number
101b	94	83	5.2	13	23	5	6	7
102b	93	82	4.4	14	25	5	7	7
103b	90	80	4.0	17	23	5	7	6
104b	88	78	3.1	15	21	3	-	6
105b	85	75	2.8	14	20	6	5	-
106b	83	73	2.7	15	18	2	4	-
107b	90	79	3.7	18	22	2	6	-
108b	92	82	4.5	11	20	5	8	6
109b	90	80	3.9	10	19	5	7	6
110b	82	72	2.8	13	17	6	-	5
111b	84	75	2.7	12	20	3	-	5
112b	85	75	2.7	14	18	3	-	-
113b	84	75	2.8	10	14	6	-	5
114b	73	64	1.5	10	10	1	-	-
115b	86	77	3.2	16	23	3	-	4
116b	95	84	4.2	10	22	5	5	2
117b	86	76	2.9	11	17	1	-	-
118b	92	82	4.2	19	23	5	8	4
119b	77	68	1.8	10	22	1	-	-
120b	81	72	2.2	17	23	-	-	-
121b	78	69	2.0	12	12	1	-	-
122b	83	73	2.7	17	20	6	4	-
123b	87	77	3.1	16	20	-	-	-
124b	87	76	3.0	19	25	1	-	-
125b	80	71	2.1	-	-	1	-	-

Appendix 1: continued

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age	Reproductive stage	Egg number	Embryo number
127b	75	67	1.8	14	16	1	-	-
128b	77	67	2.0	21	21	1	-	-
129b	80	71	2.1	15	19	1	-	-
130b	94	82	3.7	10	21	5	5	5
131b	87	77	3.3	15	24	5	5	5
132b	76	67	2.0	14	15	1	-	-
133b	84	74	2.7	16	19	1	-	-
134b	81	71	2.3	18	21	1	-	-
135b	75	66	2.1	17	17	1	-	-
136b	72	63	1.6	18	19	1	-	-
137b	80	70	2.5	14	19	1	-	-
138b	74	66	1.7	13	13	1	-	-
139b	79	70	2.0	18	20	1	-	-
140b	102	90	5.0	14	15	3	-	6
141b	85	75	3.0	14	21	1	-	-
142b	81	72	2.6	19	22	2	4	-
143b	73	64	1.7	19	21	1	-	-
144b	80	71	2.0	15	16	1	-	-
145b	75	65	1.9	16	18	1	-	-
146b	80	70	2.1	18	19	-	-	-
147b	82	71	2.9	14	16	2	5	-
148b	95	83	4.0	13	23	3	-	2
149b	91	80	3.5	17	22	2	7	-
150b	81	72	2.2	16	20	1	-	-
151b	99	90	5.1	13	25	1	7	9

Appendix 1: continued

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age	Reproductive stage	Egg number	Embryo number
152b	77	67	1.9	11	17	1	-	-
153b	86	76	2.6	12	19	1	-	-
154b	80	72	2.5	17	18	1	-	-
155b	79	69	1.9	15	18	1	-	-
156b	86	77	3.3	19	24	2	2	-
157b	85	76	3.0	16	19	-	-	-
158b	67	59	1.4	15	15	1	-	-
159b	73	63	1.5	15	15	1	-	-
160b	82	75	2.1	15	24	2	3	-
161b	95	85	4.3	14	20	5	7	6
162b	87	77	3.4	14	21	3	-	5
163b	90	81	3.5	17	22	2	3	-
164b	78	69	2.0	15	18	1	-	-
165b	70	62	1.4	12	14	1	-	-
166b	81	71	2.3	10	14	1	-	-
167b	82	71	2.5	15	16	1	-	-
168b	95	84	3.5	15	21	3	-	9
169b	78	69	2.1	21	23	1	-	-
170b	83	73	3.9	11	19	5	5	5
171b	80	71	2.0	18	19	1	-	-
172b	75	66	1.7	14	17	1	-	-
173b	79	70	2.0	14	17	1	-	-
174b	72	63	1.5			1	-	-
175b	89	79	3.4	12	19	-	-	-
176b	81	71	2.5	14	16	1	-	-

Appendix 1: continued

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age	Reproductive stage	Egg number	Embryo number
177b	84	74	3.2	19	23	2	4	-
178b	82	72	2.4	18	20	-	-	-
179b	87	77	3.3	17	21	2	4	-
180b	88	77	2.8	15	19	2	4	-
181b	104	93	4.9	6	21	3	-	7
182b	79	70	2.4	18	19	1	-	-
183b	100	89	5.1	13	19	-	-	-
184b	93	82	4.3	16	21	5	7	6
185b	80	70	2.8	18	21	2	4	-
186b	74	64	1.8	13	17	1	-	-
187b	88	77	3.3	11	19	5	3	3
188b	88	78	2.1	13	22	1	-	-
189b	85	75	3.1	20	26	5	3	6
190b	87	76	3.8	22	26	2	5	-
191b	83	74	3.1	15	20	2	5	-
192b	111	100	8.0	-	-	5	11	8
193b	90	79	3.2	12	20	5	5	3
194b	81	72	2.2	-	-	1	-	-
195b	80	70	2.4	22	26	1	-	-
196b	106	94	5.7	13	25		-	-
197b	102	92	5.4	9	20	3	8	-
198b	97	86	4.6	14	23	5	6	6
199b	78	68	2.5	12	17	-	-	-
200b	84	73	3.4	13	17	6	5	-
201b	90	78	4.2	13	23	5	7	5

Appendix 1: continued

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age	Reproductive stage	Egg number	Embryo number
202b	94	82	4.3	10	20	5	17	16
203b	81	71	2.7	14	18	1	-	-
204b	100	86	5.2	14	24	5	6	5
205b	85	73	2.8	18	21	1	-	-
206b	83	73	2.7	15	21	6	4	-
207b	86	75	3.0	19	23	1	-	-
208b	82	71	2.5	16	20	1	-	-
209b	91	79	3.2	15	21		-	-
210b	87	76	2.8	21	26	3	-	5
211b	91	80	3.5	15	21	6	4	-
212b	68	60	1.5	12	12	1	-	-
213b	74	64	2.0	14	16	1	-	-
214b	88	77	3.0	19	23	6	4	-
215b	75	65	2.2	17	18	1	-	-
216b	98	87	5.2	10	19	5	7	8
217b	80	69	2.6	16	20	1	-	-
218b	78	69	2.4			6	3	-
219b	72	63	1.6	14	15		-	-
220b	94	81	4.8	17	24	5	6	6
221b	77	67	2.0	19	20	1	-	-
222b	88	77	3.7	18	23	6	6	-
223b	83	73	3.1	15	20	6	5	-
224b	85	75	2.9			1	-	-
225b	90	79	3.8	11	19	5	6	4
226b	83	73	2.8	17	22	6	4	-

Appendix 1: continued

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age	Reproductive stage	Egg number	Embryo number
227b	79	70	2.3	20	25	1	-	-
228b	86	76	3.0	17	19	6	5	-
229b	71	62	1.5	12	12		-	-
230b	86	76	3.3	16	20	6	5	-
231b	90	80	3.7	15	20	6	5	-
232b	69	60	1.4	13	12	1	-	-
233b	87	77	3.0	19	23	1	-	-
234b	84	75	3.0	14	18	3	-	3
235b	83	73	2.9	16	22	6	6	-
236b	89	78	3.4	16	22	5	8	5
237b	69	60	1.5	14	14	1	-	-
238b	92	81	4.4	11	20	5	5	8
239b	75	65	1.8	13	14	-	-	-
240b	72	63	1.7	15	16	1	-	-
241b	82	72	2.7	13	19	1	-	-
242b	77	68	2.1	14	17	1	-	-
243b	73	64	1.6	18	19	1	-	-
244b	81	70	2.4	15	19	6	4	-
245b	80	71	2.2	17	18	1	-	-
246b	73	64	1.5	15	16	1	-	-
247b	84	74	2.8	15	19	1	-	-
248b	81	72	2.6	16	19	1		-
249b	83	74	2.7	21	25	6	4	-
250b	78	68	2.1	17	18	1	-	-
251b	86	75	3.0	22	27	6	5	-

Appendix 1: continued

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age	Reproductive stage	Egg number	Embryo number
252b	96	84	4.6	9	24	5	6	9
253b	87	77	3.2	20	25	6	5	-
254b	82	73	2.6	15	21	-	-	-
255b	83	73	3.6	20	22	5	4	2
256b	85	75	2.8	15	17	1	-	-
257b	90	79	2.9	-	-	5	6	5
258b	82	74	2.5	20	21	1	-	-
259b	102	90	6.5	13	23	-	-	-
260b	76	66	1.8	16	17	1	-	-
261b	90	79	4.4	17	23	5	6	6
262b	89	79	3.3	19	23	6	5	-
263b	82	72	2.7	15	16	1	-	-
264b	86	78	3.1	12	15	1	-	-
265b	94	84	4.7	24	31	5	7	2
266b	80	71	2.4	19	21	6	4	-
267b	80	71	2.5	14	15	6	4	-
268b	87	77	3.1	17	20	1	-	-
269b	78	69	2.4	15	17	1	-	-
270b	88	79	3.4	13	22	1	-	-
271b	83	74	2.4	15	21	1	-	-
272b	90	79	3.0	25	30	1	-	-
273b	75	66	1.7	16	19	1	-	-
274b	81	71	2.5	17	20	6	3	-
275b	74	66	1.7	15	18	1	-	-
276b	79	70	2.3	16	19	1	-	-
277b	73	64	1.7	-	-	1	-	-

Appendix 1: continued

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age	Reproductive stage	Egg number	Embryo number
278b	88	79	3.1	23	29	4	6	-
279b	78	69	2.6	15	19	1	-	-
280b	96	86	4.4	14	21	5	6	4
281b	89	79	3.4	17	23	6	6	-
282b	96	86	4.5	13	20	5	8	6
283b	76	69	2.2	19	20	1	-	-
284b	97	87	5.9	10	27	5	7	7
285b	83	79	3.4	16	22	6	5	-
286b	79	71	2.4	13	19	1	-	-
287b	85	78	3.3	16	22	1	-	-
288b	83	74	3.0	12	18	6	5	-
289b	76	67	1.9	16	20	1	-	-
290b	75	66	2.0	13	14	1	-	-
291b	71	63	1.5	13	15	-	-	-
292b	91	82	4.2	15	25	5	8	5
293b	69	60	1.8	12	11	1	-	-
294b	84	76	3.6	19	20	6	7	-
295b	85	76	3.1	18	28	6	5	-
296b	100	90	6.8	11	25	5	9	9
297b	100	89	5.5	14	20	6	9	9
298b	87	77	4.2	12	24	5	7	4
299b	84	74	3.1	21	22	6	5	-
300b	69	63	1.6	10	11	1	-	-
301b	82	74	2.8	19	20	-	-	-
302b	76	68	2.1	18	19	-	-	-

Appendix 1: continued

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age	Reproductive stage	Egg number	Embryo number
303b	100	90	4.6	-	-	4	6	7
304b	77	66	2.1	16	18	1	-	-
305b	68	62	2.0	14	19	1	-	-
306b	100	89	5.5	18	28	6	-	4
307b	104	95	5.5	-	-	5	8	8
308b	101	89	4.9	12	25	5	6	5
309b	71	64	1.6	15	16	1	-	-
310b	85	77	3.1	19	23	1	-	-
311b	78	70	2.1	14	16	1	-	-
312b	76	67	1.9	17	23	1	-	-
313b	71	63	1.7	14	15	1	-	-
314b	80	70	2.2	17	21	1	-	-
315b	77	68	2.1	13	15	1	-	-
316b	93	84	3.6	16	23	4	-	6
317b	101	90	4.6	11	21	3	-	6
318b	88	79	3.3	16	22	4	6	1
319b	81	71	2.4	19	21	1	-	-
320b	85	76	2.8	20	23	1	-	-
321b	87	77	3.3	-	-	6	5	-
322b	80	70	2.6	19	21	1	-	-
323b	73	64	1.8	12	13	1	-	-
324b	79	69	2.4	21	24	1	-	-
325b	76	67	1.9	17	20	1	-	-
326b	84	74	2.8	20	21	1	-	-
328b	78	68	1.9	18	19	1	-	-

Appendix 1: continued

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age	Reproductive stage	Egg number	Embryo number
329b	87	77	3.3	16	21	-	-	-
330b	84	75	2.8	13	15	5	6	5
331b	88	78	3.5	27	32	4	5	7
332b	95	85	3.9	13	20	2	7	-
333b	72	63	1.6	12	12	-	-	-
334b	87	75	2.9	15	25	-	-	-
335b	82	72	2.6	18	21	4	-	3
336b	85	73	2.8	21	23	1	-	-
337b	95	87	4.9	17	23	-	-	-
338b	96	87	4.5	12	21	-	-	-
339b	97	88	4.2	18	24	-	-	-
347b	82	73	2.7	17	23	5	3	5
348b	104	93	5.4	17	17	5	7	3
349b	97	86	4.8	14	22	5	7	5
350b	99	88	5.4	10	18	5	6	2
351b	78	69	2.3	18	20	-	-	-
352b	87	76	3.4	23	21	4	-	4
353b	93	82	3.3	13	20	2	-	6
360b	101	88	5.1	12	24	5	8	9
361b	109	97	6.9	13	26	5	7	6
362b	93	83	4.2	15	18	5	7	4
363b	100	90	4.6	17	29	4	-	7
364b	102	91	5.5	17	28	5	10	6
365b	109	97	7.5	12	25	5	11	10
366b	91	80	3.7	21	25	-	-	-

Appendix 1: continued

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age	Reproductive stage	Egg number	Embryo number
367b	97	86	4.3	21	27	4	10	5
368b	96	85	4.4	12	21	5	7	6
369b	97	86	5.0	21	28	5	8	7

Appendix 2: Raw data for male spiny dogfish captured in the Minas Basin from July 7 - October 10, 1996.

TL = Total length; FL = Fork length.

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age
126b	79	68	1.7	15	15
327b	83	72	2.1	12	15
340b	75	66	1.7	16	19
345b	77	68	1.9	14	-
346b	75	66	2.1	-	-
354b	86	76	2.6	14	17
355b	85	76	2.3	10	20
356b	75	66	1.9	18	21
357b	78	68	2.0	12	17
358b	80	71	2.1	15	21
359b	74	65	2.0	16	17

Appendix 3: Raw data for female spiny dogfish captured during the N246 Scotian Shelf DFO survey of July 1996.

TL = Total length; FL = Fork length.

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age	Reproductive stage	Egg number	Embryo number
1a	67	57	1.135	13	13	1	-	-
2a	72	63	1.345	10	13	1	-	-
3a	77	68	1.785	15	19	1	-	-
4a	64	56	1.005	11	-	1	-	-
5a	80	71	2.035	17	19	1	-	-
6a	83	72	2.250	14	17	1	-	-
7a	67	59	1.265	14	14	1	-	-
8a	57	50	0.630	4	4	1	-	-
9a	70	60	1.295	13	14	1	-	-
10a	82	72	2.340	15	18	2	4	-
21a	57	50	0.895	9	9	1	-	-
22a	63	56	1.050	12	12	1	-	-
23a	60	53	0.905	11	11	1	-	-
24a	68	60	1.335	14	14	1	-	-
25a	79	69	2.160	15	19	1	-	-
26a	81	71	2.650	35	36	1	-	-
27a	72	63	2.340	19	21	1	-	-
28a	63	56	1.015	9	9	1	-	-
29a	53	46	0.630	10	10	1	-	-
30a	70	62	1.345	16	17	1	-	-
51a	78	68	2.202	21	26	2	5	-
52a	84	74	2.606	14	18	5	-	4
53a	78	68	2.034	12	15	-	-	-
54a	75	67	1.714	20	25	1	-	-
55a	70	61	1.416	20	22	1	-	-

Appendix 3: continued

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age	Reproductive stage	Egg number	Embryo number
56a	74	66	1.920	15	16	1	-	-
57a	67	58	1.188	16	16	1	-	-
58a	83	75	2.532	17	22	1	-	-
59a	81	72	2.240	19	25	1	-	-
60a	58	52	0.762	8	8	1	-	-
61a	77	68	1.876	13	18	-	-	-
62a	69	61	1.430	9	9	-	-	-
63a	77	68	1.812	11	13	1	-	-
64a	67	59	1.354	17	18	-	-	-
65a	76	67	2.028	17	19	-	-	-
66a	73	65	1.688	17	17	-	-	-
75a	68	60	1.365	12	15	1	-	-
76a	77	67	1.885	15	18	1	-	-
77a	74	67	1.760	13	18	1	-	-
78a	55	48	0.720	6	6	1	-	-
79a	74	65	2.140	11	14	1	-	-
88a	82	72	2.355	14	15	1	-	-
89a	74	65	1.620	17	21	1	-	-
90a	72	63	1.640	12	12	1	-	-
94a	74	63	1.415	13	14	1	-	-
97a	81	73	2.290	16	22	1	-	-
98a	66	58	1.215	10	10	1	-	-
99a	77	68	1.885	13	13	1	-	-
111a	74	64	1.870	12	18	1	-	-
112a	59	51	0.825	8	8	1	-	-

Appendix 3: continued

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age	Reproductive stage	Egg number	Embryo number
113a	72	63	1.450	18	20	1	-	-
114a	74	65	1.745	16	19	1	-	-
115a	69	61	1.395	14	16	1	-	-
116a	87	76	3.155	15	22	5	5	5
117a	72	64	1.370	20	23	1	-	-
118a	79	70	2.245	11	17	1	-	-
119a	71	62	1.435	20	22	1	-	-
120a	80	71	2.320	16	17	1	-	-
121a	77	69	1.855	17	20	-	-	-
130a	69	61	1.460	17	19	1	-	-
132a	68	60	1.355	13	13	1	-	-
138a	66	58	1.190	13	13	1	-	-
139a	74	65	1.600	23	26	1	-	-
146a	69	61	1.310	30	31	1	-	-
147a	78	68	2.070	20	24	1	-	-
154a	70	62	1.665	16	21	1	-	-
157a	57	51	0.760	11	11	1	-	-
158a	65	57	1.155	13	13	1	-	-
159a	67	58	1.165	11	1	1	-	-
160a	61	53	0.955	12	12	1	-	-
161a	74	66	1.680	12	14	1	-	-
162a	65	57	1.195	12	12	-	-	-
163a	63	55	0.990	11	11	1	-	-
164a	80	71	2.210	17	20	1	-	-
165a	77	68	2.175	18	20	1	-	-

Appendix 3: continued

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age	Reproductive stage	Egg number	Embryo number
167a	68	61	1.300	14	14	1	-	-
177a	63	55	1.160	11	11	1	-	-
183a	75	67	1.855	-	-	1	-	-
184a	59	51	0.870	14	14	1	-	-
185a	63	55	0.945	12	12	1	-	-
186a	71	63	1.490	17	17	1	-	-
193a	67	59	1.315	17	17	1	-	-
194a	52	46	0.565	11	11	1	-	-
195a	67	58	1.410	10	10	1	-	-
196a	64	55	1.020	15	15	1	-	-
198a	74	64	1.535	12	14	1	-	-
199a	58	51	0.760	10	10	1	-	-
205a	51	44	0.455	8	8	1	-	-
210a	29	26	0.085	4	4	1	-	-
212a	30	26	0.105	3	3	1	-	-
215a	29	25	0.090	3	3	1	-	-

Appendix 4: Raw data for male spiny dogfish captured during the N246 Scotian Shelf DFO survey of July 1996. TL = Total length; FL = Fork length.

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age
11a	83	73	2.010	17	21
12a	77	68	1.820	13	16
13a	67	39	1.120	11	11
14a	67	59	1.155	11	11
15a	71	62	1.360	27	29
16a	56	49	0.725	8	8
17a	68	60	1.210	11	11
18a	75	67	1.605	17	19
19a	73	65	1.585	5	16
20a	65	57	1.105	-	-
31a	77	67	1.955	14	17
32a	68	61	1.355	11	12
33a	74	66	1.625	16	18
34a	55	49	0.730	9	9
35a	63	55	1.105	5	9
36a	69	61	1.340	15	15
37a	66	58	1.220	11	11
38a	67	58	1.180	12	12
39a	78	68	1.800	11	17
40a	62	55	1.005	7	13
41a	85	74	2.416	7	14
42a	72	64	1.582	-	-
43a	62	55	0.984	13	13
44a	79	71	2.176	13	25
45a	76	66	1.730	11	15

Appendix 4: continued

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age
46a	69	56	1.262	10	16
47a	61	54	0.942	9	9
48a	86	77	2.416	8	19
49a	65	57	1.110	12	12
50a	66	58	1.248	13	13
67a	79	69	2.176	8	17
68a	77	68	1.730	7	13
69a	67	59	1.274	12	12
70a	72	64	1.394	18	-
71a	74	65	1.662	10	12
72a	72	64	1.396	14	18
73a	76	57	1.704	15	19
74a	69	60	1.322	11	11
80a	69	61	1.480	15	17
81a	64	56	0.995	13	13
82a	74	64	1.735	11	21
83a	73	64	1.565	8	8
84a	65	58	1.115	9	12
85a	84	75	2.255	-	-
86a	70	62	1.555	15	15
87a	71	62	1.835	10	13
91a	77	67	1.715	17	22
92a	71	62	1.350	6	10
93a	74	65	1.660	15	20
95a	83	74	2.330	11	16

Appendix 4: continued

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age
96a	75	66	1.640	7	10
100a	71	62	1.530	10	14
101a	68	59	1.285	17	17
102a	79	70	1.875	15	18
103a	77	68	1.890	18	21
104a	67	59	1.395	16	17
105a	65	57	1.245	13	11
106a	75	68	1.865	-	-
107a	69	61	1.250	18	17
108a	70	62	1.460	16	16
109a	69	61	1.140	11	11
110a	68	69	1.780	12	18
122a	64	57	0.990	14	14
123a	77	68	1.910	11	15
124a	71	63	1.405	17	17
125a	69	62	1.300	16	16
126a	77	68	1.595	11	14
127a	75	66	1.545	15	16
128a	82	73	2.015	10	23
129a	84	73	2.515	20	27
131a	74	65	1.550	16	16
133a	78	68	1.845	23	27
134a	75	66	1.540	18	20
135a	74	65	1.860	20	23
136a	72	63	1.575	19	21

Appendix 4: continued

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age
137a	70	61	1.345	15	15
140a	78	69	1.780	13	17
141a	71	62	1.455	13	19
142a	80	71	1.870	8	-
143a	77	69	1.865	11	15
144a	81	72	2.210	10	19
145a	66	58	1.195	17	17
148a	74	66	1.755	23	23
149a	63	56	1.005	19	19
150a	69	61	1.335	15	16
151a	73	65	1.580	19	26
152a	68	60	1.150	17	17
153a	79	71	2.095	21	25
155a	64	57	1.025	17	17
156a	74	65	1.470	14	15
162a	65	57	1.195	12	12
166a	79	70	2.000	12	15
168a	79	70	2.270	13	18
169a	66	59	1.135	15	15
170a	77	68	1.730	16	16
171a	71	62	1.590	16	17
172a	71	63	1.630	15	16
173a	72	64	1.390	10	10
174a	69	61	1.310	12	13
175a	66	59	1.130	9	9

Appendix 4: continued

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age
176a	61	54	0.900	12	12
178a	63	55	0.935	10	10
179a	73	63	1.510	13	14
180a	71	63	1.235	16	17
181a	73	65	1.525	11	11
182a	71	63	1.450	14	15
187a	75	66	1.590	13	13
188a	76	67	1.620	-	-
189a	53	46	0.645	6	6
190a	57	50	0.775	8	8
191a	56	49	0.600	6	6
192a	71	63	1.335	12	14
197a	69	60	1.255	17	20
200a	74	64	1.405	13	14
201a	77	68	1.875	10	13
202a	73	65	1.455	13	13
203a	69	61	1.070	11	11
204a	64	57	0.925	10	10
206a	77	68	1.700	6	9
207a	60	54	0.925	10	10
208a	76	67	2.160	-	-
209a	69	62	1.225	9	11
211a	25	29	0.075	2	2
213a	25	28	0.075	3	3
214a	37	41	0.280	4	4

Appendix 5: Raw data for female spiny dogfish captured during the N249 Gulf of St. Lawrence DFO survey of September 1996. TL = Total length; FL = Fork length.

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age	Reproductive stage	Egg number	Embryo number
2d	67	60	1.285	14	14	1	-	-
3d	86	77	2.756	20	26	1	-	-
4d	76	66	1.886	15	22	1	-	-
5d	70	62	1.188	13	12	1	-	-
8d	87	77	2.306	18	22	1	-	-
9d	87	77	2.920	13	13	5	3	5
20d	85	76	2.870	12	18	6	4	-
21d	90	79	3.26	17	18	3	-	5
22d	85	76	2.88	17	21	1	-	-
23d	101	89	5.12	11	15	3	-	7
24d	64	57	1.18	12	14	1	-	-
25d	73	64	1.64	11	14	1	-	-
26d	80	70	2.35	14	17	1	-	-
27d	66	56	1.31	9	9	1	-	-
28d	88	78	3.41	15	20	3	-	4
29d	93	82	3.98	16	18	3	-	6
30d	97	86	3.86	12	17	3	-	5
31d	98	86	4.27	-	-	1	-	-
32d	95	84	4.18	12	25	3	-	7
33d	76	67	1.59	18	20	1	-	-
35d	92	82	3.67	15	21	3	-	3
36d	93	81	3.12	12	18	1	-	-
37d	89	78	2.50	14	20	1	-	-
38d	79	69	1.86	11	16	1	-	-
39d	82	73	2.11	17	19	1	-	-

Appendix 5: continued

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age	Reproductive stage	Egg number	Embryo number
40d	81	71	2.23	13	19	3	-	3
41d	79	69	2.02	12	17	1	-	-
42d	81	71	2.24	14	17	1	-	-
43d	81	71	2.11	11	13	1	-	-
44d	82	72	2.32	8	15	1	-	-
51d	93	82	3.67	-	-	4	-	4
52d	67	59	1.16	14	14	1	-	-
53d	88	78	2.89	16	21	1	-	-
54d	84	74	2.15	15	16	1	-	-
55d	78	68	1.71	12	13	1	-	-
56d	78	68	1.70	13	13	1	-	-
63d	88	78	2.92	21	23	1	-	-
64d	85	75	3.23	12	17	3	-	3
65d	96	85	3.70	18	23	1	-	-
66d	87	77	3.38	17	22	5	6	3
69d	84	75	2.39	22	27	-	-	-
70d	86	76	2.89	21	23	3	-	3
71d	75	67	1.97	12	18	1	-	-
72d	91	81	3.41	16	21	3	-	3
73d	89	79	3.00	17	22	5	4	3
74d	91	80	3.38	18	22	6	1	-
75d	88	78	2.65	17	24	1	-	-
76d	81	72	2.32	18	19	1	-	-
77d	82	72	2.56	18	20	1	-	-
80d	86	76	3.06	-	-	1	-	-

Appendix 5: continued

Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age	Reproductive stage	Egg number	Embryo number
82d	78	68	1.70	16	18	1	-	-
83d	82	71	2.41	10	17	6	6	-
84d	77	67	2.02	12	13	1	-	-
86d	65	56	1.08	10	10	1	-	-
93d	77	67	1.40	12	21	1	-	-
94d	78	68	1.90	20	22	1	-	-
95d	73	63	1.70	17	19	1	-	-
96d	76	66	1.50	17	18	1	-	-
97d	80	70	2.20	16	19	1	-	-
98d	75	65	1.40	15	16	1	-	-
99d	79	68	1.80	21	22	1	-	-
109d	78	68	2.17	15	20	1	-	-
110d	78	68	2.17	15	15	1	-	-
111d	64	56	1.16	15	15	1	-	-
112d	64	55	0.90	19	22	1	-	-
113d	77	68	1.80	-	-	1	-	-
114d	75	65	1.80	17	19	1	-	-

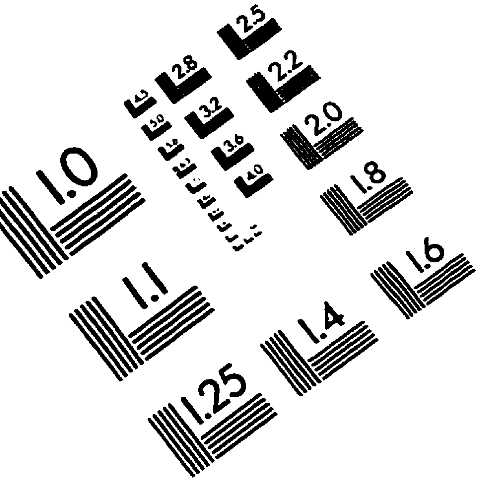
Appendix 6: Raw data for male spiny dogfish captured during the N249 Gulf of St. Lawrence DFO survey of September 1996. TL = Total length; FL = Fork length.

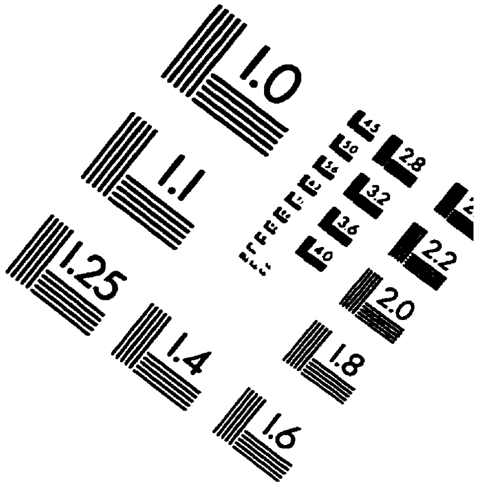
Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age
1d	75	64	1.596	21	23
6d	87	77	2.506	5	16
7d	72	63	1.516	21	22
10d	70	60	1.540	11	12
11d	74	65	1.64	13	17
12d	79	69	1.96	12	14
13d	81	70	2.05	13	16
14d	77	68	1.97	15	16
15d	79	69	2.39	9	10
16d	75	65	1.88	3	12
17d	69	61	1.37	11	16
18d	76	67	1.77	7	15
19d	81	71	1.83	5	23
34d	84	74	1.98	17	21
45d	75	66	1.54	11	13
46d	76	67	1.62	-	-
47d	78	69	2.12	10	13
48d	78	68	1.87	13	15
49d	84	74	2.15	10	17
50d	73	63	1.37	10	11
57d	79	69	1.70	13	16
58d	80	70	1.80	12	18
59d	79	69	1.67	11	14
60d	71	62	1.39	17	17
61d	71	63	1.07	18	18

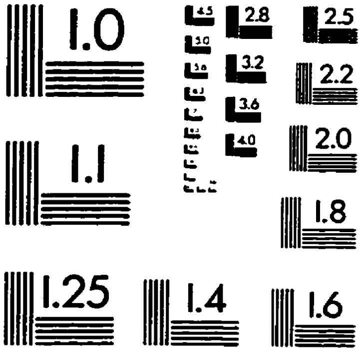
Appendix 6: continued

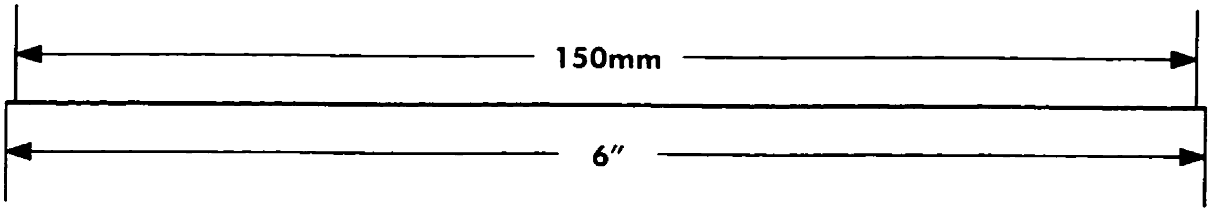
Label	TL (cm)	FL (cm)	Weight (kg)	Counted age	Calculated age
62d	70	61	1.17	12	12
67d	79	71	2.09	11	13
68d	78	69	1.98	7	14
79d	77	67	1.88	16	21
81d	68	59	1.10	10	10
85d	69	61	1.30	9	9
87d	78	68	1.88	10	14
88d	74	64	1.43	12	14
89d	72	64	1.37	9	13
90d	65	57	0.98	13	13
91d	77	68	1.83	16	19
92d	73	63	1.40	13	22
100d	77	67	1.6	15	17
101d	75	65	1.5	17	21
102d	74	64	1.5	17	17
103d	72	62	1.5	13	14
104d	75	66	1.7	-	-
105d	75	65	1.5	13	16
106d	82	72	2.3	-	-
107d	76	66	1.7	-	-
108d	71	62	1.4	23	24

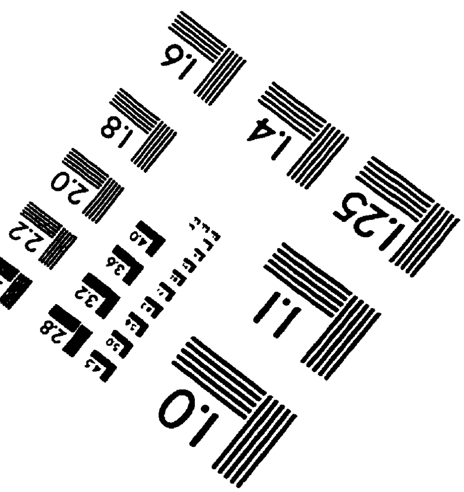
IMAGE EVALUATION
TEST TARGET (QA-3)

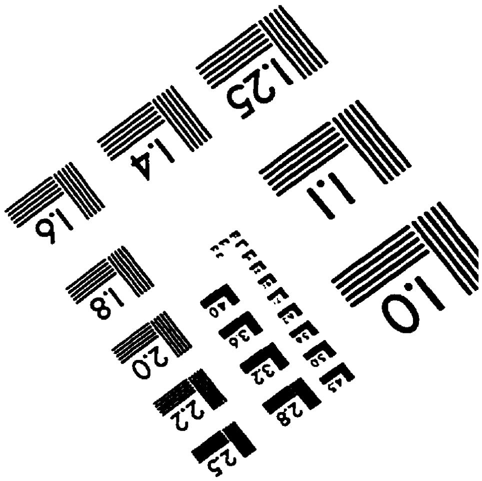












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