B. Spiny Dogfish (*Squalus acanthias*)

1.0 Introduction

The Atlantic States Marine Fisheries Commission (ASMFC) Spiny Dogfish Stock Assessment Subcommittee and the Stock Assessment Review Committee (SARC) Southern Demersal Working Group meet jointly during May 12-14, 2003 at the NEFSC in Woods Hole, MA to develop the spiny dogfish stock assessment for 2003. The following scientists and managers participated in the meeting:

Jim Armstrong	Mid-Atlantic Fishery Management Council
Laurel Col	NMFS NEFSC
Eric Dolan	NMFS NERO
Megan Gamble	ASMFC
Joe Grist	North Carolina Division of Marine Fisheries
Ralph Mayo	NMFS NEFSC
Steve Murawski	NMFS NEFSC
Loretta O'Brien	NMFS NEFSC
Chris Powell	Rhode Island Division of Fish and Wildlife
Paul Rago	NMFS NEFSC
Jim Ruhle	Mid-Atlantic Fishery Management Council
Roger Rulifson	East Carolina University
Alexi Sharov	Maryland Department of Natural Resources
Katherine Sosebee	NMFS NEFSC
Mark Terceiro (chair)	NMFS NEFSC

2.0 Terms of Reference

The Terms of Reference for the assessment were as follows:

1) Characterize the commercial and recreational catch (landings and discards) for the entire stock (includes Canadian catch) and identify methods for improving the accuracy of discard and discard mortality estimates.

2) Estimate current and historic fishing mortality, spawning stock biomass, and total stock biomass and characterize the uncertainty of those estimates.

3) Update or re-estimate biological reference points (including rebuilding targets) as appropriate.

4) Estimate yield based on stock status and target mortality rate (F = 0.08) for fishing year 2004 (May, 2004 through April, 2005).

5) Provide short term projections (2-3 years) of stock status under a variety of TAC/F strategies

6) Evaluate existing and alternative rebuilding schedules based on current/projected stock status.

7) Provide estimates of juvenile recruitment and pupping rates. Characterize the uncertainty of these estimates.

8) Characterize the level of discards, bycatch rates, discard mortality rates, and length and sex data for spiny dogfish (per trip, per net, etc.) in directed and bycatch fisheries and how changes in regulations and fishing practices may have affected these rates.

3.0 Overview

Spiny dogfish (*Squalus acanthias*) are distributed in Northwest Atlantic waters between Labrador and Florida, are considered to be a unit stock in NAFO Subareas 2-6, but are most abundant from Nova Scotia to Cape Hatteras. Seasonal migrations occur northward in the spring and summer and southward in the fall and winter and preferred temperatures range from 7.2° to 12.8°C (Jensen 1965). In the winter and spring, spiny dogfish are located primarily in Mid-Atlantic waters but also extend onto southern Georges Bank on the shelf break. In the summer, they are located further north in Canadian waters and move inshore (into bays and estuaries). By autumn, dogfish have migrated north with high concentrations in Southern New England, on Georges Bank, and in the Gulf of Maine. They remain in northern waters throughout the autumn until water temperatures begin to cool and then return to the Mid-Atlantic.

Dogfish tend to school by size and, for large mature individuals, by sex. Dogfish are major predators on some commercially important species, mainly herring, Atlantic mackerel, and squid, and to a much lesser extent, haddock and cod. Maximum reported ages for males and females in the Northwest Atlantic were estimated by Nammack (1982) to be 35 and 40 years, respectively, whereas ages as old as 70 years have been determined for spiny dogfish off British Columbia (McFarlane and Beamish 1987). In this paper, a maximum age of 50 years was assumed. Sexual maturity occurs at a length of about 60 cm for males and 75 cm for females (Jensen 1965). Reproduction occurs offshore in the winter (Bigelow and Schroeder 1953), and female dogfish bear live offspring. The gestation period ranges from 18 to 22 months with 2 to 15 pups (average of 6) produced. Females attain a greater size than males, reaching maximum lengths and weights up to 125 cm and 10 kg, respectively.

4.0 Fishery-Dependent Information

4.1 Commercial Landings

Commercial landings data and biological information were obtained from the NEFSC commercial fisheries database. The sex of commercial landings was not recorded routinely until 1982. The commercial landings sampling program is described in Burns et al. (1983). Historical records dating back to 1931 indicate levels of US commercial landings of dogfish in Subareas 5 and 6 of less than 100 mt in most years prior to 1960 (NEFC 1990). Total landings of spiny dogfish in NAFO Subareas 2-6 by all fisheries climbed rapidly from the late 1960s to a peak of about 25,000 metric tons (mt) in 1974 (Table 4.1). Substantial harvests of dogfish by foreign trawling fleets began in 1966 in Subareas 5 and 6 and continued through 1977. Since 1978, landings by foreign fleets have been curtailed, and landings by US and Canadian vessels have increased markedly. A sharp intensification of the US commercial fishery began in 1990; estimated landings in 1996, in excess of 28,000 mt, were about five times greater than the 1980-1989 average. Landings between 1997 and 1999 averaged about 20,000 mt. Landings in 2001 and 2002 dropped dramatically with the large landings reductions imposed by federal and ASMFC management plans.

4.1.1 US landings

US commercial landings of dogfish from NAFO Subareas 2-6 were around 500 mt in the early 1960s (Table 4.1), dropped to levels as low as 70 mt during 1963-1975 while averaging about 90 mt, and remained below 1,000 mt until the late 1970s. Landings increased to about 4,800 mt in 1979 and remained fairly steady for the next ten years at an annual average of about 4,500 mt. Landings increased sharply to 14,900 mt in 1990, dropped slightly in 1991, but continued a rapid expansion from 18,987 mt in 1992 to over 28,000 mt in 1996. Landings in 1996 were the highest recorded since 1962, exceeding previous peak years during the early 1970's when the fishing fleet was dominated by foreign vessels (Figure 1). Landings declined in in 1997 and 1998 to around 20,000 mt. In 1999, the last full year unaffected by regulations, the landings declined to 14,860 mt. US landings dropped to about 2,200 mt in 2001 and 2002 in response to quota restrictions.

4.1.2 Foreign landings

A substantial foreign harvest of dogfish occurred mainly during 1966-1977 in Subareas 5 and 6. Landings, the bulk of which were taken by the former USSR, averaged 13,000 mt per year and reached a peak of about 24,000 mt in 1972 and 1974 (Table 4.1). In addition to the former USSR, other countries which reported significant amounts of landings include Poland, the former German Democratic Republic, Japan, and Canada. Since 1978, landings have averaged only about 900 mt annually and, except for those taken by Japan and Poland, have come primarily from Subareas 4 and 3. Canadian landings, insignificant until 1979 when 1,300 mt were landed, have been sporadic, but again totaled about 1,300 mt in 1990. Canadian landings increased about nine-fold between 1996 and 2001 with landings of 3,755 mt in 2001. Landings in 2002 have not been finalized but should range between 3,000 and 3,400 mt (Steve Campana, DFO personal comm.).

4.1.3 Gear types

The primary gear used by US fishermen to catch spiny dogfish has been otter trawls and sink gill nets (Table 4. 2, Figure 4.2). The latter accounted for over 50% of the total US landings during the 1960s, while the former was the predominant gear through the 1970s and into the early 1980s. During the peak period of exploitation in the 1990s sink gill nets were the dominant gear. Landings in otter trawls ranged around 3,000 – 5,000 mt during this period. Both otter trawl and gill net landings decreased markedly in 2001, coincident with the rise in landings by hook gear. Landings of dogfish in drift gillnets peaked in 1998 with over 1,300 mt landed but have since declined to near zero. Spiny dogfish taken by the distant water fleets were caught almost entirely by otter trawl. Recent Canadian landings have been mainly by gill nets and longlines.

4.1.4 Temporal and spatial distribution

The temporal and spatial pattern of dogfish landings are closely tied to the north-south migration patterns of the stock. Peak landings from May through October coincide with residency of dogfish along the southern flank of Georges Bank, the Gulf of Maine and the near shore waters around Massachusetts. As the population migrates to the south in late fall and early winter, landings increase in the southern states, especially North Carolina. US dogfish landings have been reported in all months of the year, but most landings traditionally occur from June through September (Table 4.3). During the peak years of the domestic fishery, substantial quantities were also taken during autumn and winter months.

Landings by statistical area were not updated for this assessment. As reported in SARC 19 (NEFSC 1994) most landings during the 1980's originated from statistical area 514 (Massachusetts Bay). Following the intensification of the fishery in 1990, statistical areas 537 (Southern New England) and 621 (off Delmarva and southern New Jersey) produced substantial quantities. In 1992 and 1993, large landings were reported from statistical areas 631 and 635 (North Carolina).

In most years since 1979, the bulk of the landings occurred in Massachusetts (Table 4.4). Other states with significant landings include New Jersey, Maryland, and Virginia. Landings in North Carolina peaked in 1996 at 6,200 mt, about half of the Massachusetts landings, but dropped sharply to about 1,300 mt between 1997 and 2000. North Carolina landings in 2001-2002 were negligible. In 2001 and 2002, virtually all of the landings were taken north of Rhode Island.

4.2 Recreational Landings

Estimates of recreational catch of dogfish were obtained from the NMFS Marine Recreational Fishery Statistics Survey MRFSS (see Van Voorhees et al. 1992 for methodology). Recreational catch data have been collected consistently since 1979 but sex is not recorded. Methodological differences between the current survey and intermittent surveys before 1979 preclude the use of the earlier data. The MRFSS consists of two complementary surveys of anglers via on-site interviews and households via telephone. The angler-intercept survey provides catch data and biological samples, while the telephone survey provides a measure of overall effort. Surveys are stratified by state, type of fishing (mode), and sequential two-month periods (waves). For the purposes of this paper, annual catches pooled over all waves and modes and grouped by subregion (ME to CT, NY to VA, and NC to FL) were examined.

The MFRSS estimates are partitioned into three categories of numbers caught and landed: A, B1, and B2. Type A catches represent landed fish enumerated by the interviewer, while type B1 are landed catches reported by the angler. Type B2 catches are those fish caught and returned to the water. Inasmuch as dogfish are generally caught with live bait and are often mishandled by anglers, 100% discard mortality was assumed. The MRFSS provides estimates of landings in terms of numbers of fish. Biological information on dogfish is generally scanty, resulting in wide annual fluctuations in mean weights. To compute total catch in mt, an average weight of 2.5 kg per fish was assumed for all years.

Total recreational catches increased from an average of about 350 mt per year in 1979-1980 to about 1,700 mt in 1989-1991 (Table 4.1). Since 1991 recreational landings have decreased continuously from nearly 1,500 mt to less than 400 mt in 1996. Landings by number (Figure 4.3) suggest a similar, but less pronounced decline. During the 1990s, recreational landings represented a small fraction of the total fishing mortality on spiny dogfish. Even if all of the Type B2 catch died after release, recreational catches have comprised only about 8% of the total landings during this period. In 2001 and 2002 estimated B2 catches increased sharply. Total recreational catches represent about 25% of the landings in those years. As most of the recreational landings are discarded, with discarding unlikely to be size or sex selective, recreational landings were added to the total discard estimates in this assessment. This treatment of the data will be discussed more fully in Section 7.

4.3 Size and Sex Composition of Commercial Landings

The seasonal distribution of biological sampling of the landings generally coincided with the seasonal pattern of landings (Table 4.5). Most samples were taken in June through November with much lower effort from January to May. In addition to the samples listed in Table 4.5, port samples obtained by MADMF in 2000 (15) and 2002(8) (provided by Brian Kelly, MADMF), were incorporated into the analyses. These samples provided a substantial increase to the total number of measured fish in these years. The biological characteristics of the landings are driven primarily by the marketplace, particularly the acceptance of small dogfish. The major increase of small males in the 1996 landings probably reflects their acceptance by export markets as well as the availability of processing equipment for smaller dogfish. The estimated size and sex composition of the landings are based on pooled samples over the entire year.

From 1982 to 1995, over 95% of the sampled landings of spiny dogfish were females greater than 84 cm. Males comprised a small fraction of the landings and were rarely observed above 90 cm in length. In 1996 landings of male dogfish increased dramatically, both in numbers and total weight (Table 4.6). The increased fraction of male dogfish in the landings continued through 1999 but dropped markedly from 2000 through 2002. Presumably, the drop in total quota resulted in a return to the remaining large females in the population.

Shifts in length frequencies toward smaller sizes reflect the marked increase in landings since 1989. The average size of landed females appears to have decreased by more than 15 cm since 1988 (Figure 4.4, top). The average size of males dropped about 5 cm between1994 and 2000 (Figure 4.4 bottom). Reductions in average weight of females (Figure 4.5) are dramatic with a decline of average individual weight greater than 2 kg per fish since 1992. Again, the decline for males in 1996 is evident (Figure 4.5) but the drop is about 25% for males in contrast to the 50% decrease for females. Decreases in average size are consistent with increased fishing mortality, but could also be due to changes in the mix of otter trawl and sink gill net catches. Corroboration of these trends in the research surveys (later section) suggest that these trends are the result of increased fishing mortality.

Mean sizes in the commercial fishery have declined to the extent that the increase in total landings of 14,731 mt in 1990 to 27, 241 mt in 1996 (an increase of 85%) was accompanied by a 311% increase in numbers landed. Percentage of males in the landed jumped dramatically in 1996 to 17% by weight and 25% by numbers. Commercial landings by weight in 1999 (17,327 mt) were about equal to those in 1992 (17,687 mt) but the decrease in average weight resulted in the removal of almost twice as many dogfish (9.3 million fish versus 4.6 million fish). The relative increase in number killed as a function of average size can be evaluated by considering mean lengths of the landed fish (Figure 4.6 top) . For example, a decline of average size from 95 cm to 70 cm in females would imply a 3-fold increase in the total numbers removed . A drop from 95 to 85 cm average size would result in a 50% increase. Switching to male dogfish would result in even more severe increases in numbers killed since the weight at length for males is less than for females of the same length (Figure 4.6). As an illustration, a switch from 85 cm females to 80 cm males would imply 50% more deaths of males for the same landings weight. The effects of selectivity will be characterized more fully in Section 7.3.2 when fishing mortality rates are considered.

4.4 Discards

Methods

Owing to their ubiquitous distribution, dogfish are caught in a wide variety of fisheries. Owing to their low price per pound and need for special handling procedures onboard, dogfish are often discarded if more valuable species are present. Hence, high rates of dogfish bycatch and discards are expected. Previous assessments of spiny dogfish in the Northeast US have emphasized the need to estimate discard rates in other fisheries. In NEFSC (1994) preliminary analysis suggested that total discards were about the same order of magnitude at the commercial fishery. SARC 19 accepted provisional estimates of discard morality of 0.75 in gillnets and 0.5 in otter trawls but noted the considerable uncertainty in these estimates. To our knowledge, no scientific studies of post-capture survival rates have been conducted for spiny dogfish. Ongoing tagging studies by Roger Rulifson (East Carolina State University, pers. comm.) may provide indirect evidence of these important parameters.

The primary database for discard estimates in the Northeast began in 1989 with the advent of a large-scale fisheries observer program for commercial vessels (Murawski et al. 1995, Anderson 1992). Species catch, effort, and associated biological and fishery data are collected for each trip. Previous estimates of dogfish discards used a ratio estimator to expand the sample discard rates to the total population. A primary component of this expansion was the reliance on the skipper's characterization of "primary species sought". Total estimates of dogfish discards were expanded by multiplying the discard/ton ratio by the total tonnage of landings of the target species. Previous estimates of dogfish discards were hampered by low sample sizes in major gear/area/target species cells.

The ratio-estimator concept was expanded in this study in several important ways. First, the target species were defined by first identifying 21 species groups or associations (Table 4.7).

These associations were determined via consultations with stock assessment scientists within NEFSC. Similarly, fisheries were grouped in to general gear types (Table 4.8) wherein minor differences among gears were ignored. The objective of the grouping by species and gear types was to increase the number of samples available for estimation of the discard ratios from the fishery observer program and to allow for estimation of variance estimates. Likely differences among areas were aliased by the choice of species groups. For example, the principal groundfish category encompasses most of the Gulf of Maine (GOM) and Georges Bank (GB) areas, where as the fluke-four spot flounder species group aliases the Mid-Atlantic flatfish fishery. The flatfish group (witch, yellowtail, plaice, winter, windowpane, southern, hogchoker), in general, aliases the GOM, GB and Southern New England (SNE) areas. Second, the primary species group was identified post hoc by the actual landings pattern within the observed trip. The primary species was identified as the most abundant species group (by weight) within the set of 21 possible species groups. Third, we tested the relationship between the discard rate and the primary species group landed. One of the key assumptions of ratio estimators is that the predictor variable (i.e., primary species group) should be positively correlated with the dependent variable (i.e., dogfish discards). Finally, we estimated the variance of the discard estimates using the approximate variance approach of Cochran (1963, see also Fogarty and Gabriel, 2003, unpublished report).

To test whether the species grouping method sufficiently characterized the total landings of the observed trip, the relationship between total landings and primary species was plotted for all gears and species groups (Figure 4.7), trawl gear (Figure 4.8) and gill nets (Figure 4.9). In all instances the post hoc identification of primary species group appears to characterize the overall landings from the trip. For trips with over 1,000 pounds of total landings, the primary species group generally comprised more than 75% of the total landings. In contrast, the second most abundant species group had a much weaker association with the total landings (bottom panels of Figures 4.7-4.9).

Given an acceptable predictive ability to define the primary species group, the second critical requirement is that the dogfish discard level should be proportional to the landings of the primary species group. This assumption is tested by plotting observed dogfish discards versus the observed primary species group landings for all gears, years, and species groups (Figure 4.10), all years and species groups in observed trawl gear trips (Figure 4.11 top), and all years and species groups in observed gill net gear trips (Figure 4.11 bottom). The associations between discards and landings were positive, as expected, but the magnitude of the variation suggested that some species groups might have weaker associations. Examination of individual species groups plots (not shown in this report) suggested that certain species groups were only weakly related to dogfish discards. For example, no further consideration was given to discards in the large pelagic, mollusk, other sharks, other fish categories (Table 4.7).

The ratio of dogfish discards to primary species landed is multiplied by the total landings of the species group within the gear group. In order for this estimator to be reliable, it is important to consider the relationship between the observed landings and the total landings reported in the dealer records. The ratio of these two quantities can be considered the sampling ratio. The inverse of this quantity is the expansion factor that will be applied to the total observed dogfish discards. For example, a sampling rate of 0.001 would imply an expansion factor of 1000 and a concomitant increase in the sampling variability. Plots of the sampling rates for the primary species groups versus year suggest an overall sampling rate of about 0.01 since 1990 (Figure 4.12). For trawl gear (Figure 4.13) the sampling rate is about 0.05, but for gill nets, the sampling rate seems to be clustered around 0.03 to 0.05 (Figure 4.14). The lower panels of Figures 4.12-4.14 show the degree of association between the total landing of the species groups from the dealer records (x axis) and the total landings observed during sea-sampling trips. Again, the relationship appears stronger for the gill net gear than for trawls, but both groups' relationships seem acceptable.

Collectively, the results presented in Figures 4.7 to 4.14 were considered sufficient to proceed with the computation of discard rates based on landings within the trawl and gill net gear groups, and the following species groups: Atlantic herring, crustaceans, dogfish, flatfish, fluke- four spot, mackerel, menhaden, monkfish, principal groundfish, scup-sea bass, skates, small-mesh groundfish, and squid-butterfish. A completely parallel set of analyses were conducted using a trip-based ratio estimator. These analyses gave similar results to the catch-based ratio estimator but appeared to be more variable. The subcommittee considered both sets of information and recommended the use of the catch-based estimator. Of particular concern was the lack of consideration of trip duration, and variations in vessel power. More detailed analyses, perhaps using GLM or Generalized Additive Models (GAM) could be used to more precisely identify the association between effort and discards.

Means and variances of the discard estimates were computed using standard formula for ratio estimators per Cochran (1963). For completeness, these estimators are summarized below.

$D_{G,S,T}$= Observed discards of dogfish in gear G for target species S and trip T

$L_{G,S,T}$=Landings of target species S in gear G and trip T

$L_{G,S}$= Landings of species S in gear G

$$D_{TOT} = \sum_{G} \sum_{S} \left(\frac{\sum_{T} D_{G,S,T}}{\sum_{T} L_{G,S,T}} \right) L_{G,S}$$

The approximate variance is estimated by assuming that the dealer records of landings are measured with negligible reporting error and that most of the error obtains from the variance of the discard ratio R.

Let

$$\hat{R}_{G,S} = \left(\frac{\sum_{T} D_{G,S,T}}{\sum_{T} L_{G,S,T}} \right)$$

$$V\,(D_{G,S}) = V\,(\hat{R}_{G,S})\,L^{2}{}_{G,S}$$

Where

$$V(\hat{R}_{G,S}) = \frac{\left(\hat{\sigma}^{2}_{D,G,S} + \hat{R}^{2}_{G,S}\hat{\sigma}^{2}_{L,G,S} - 2\hat{R}^{2}_{G,S}\,\mathrm{cov}(,\hat{\sigma}_{L,G,S}\hat{\sigma}_{D,G,S})\right)}{\left(\sum_{T} \overline{L}\;{}_{G,S,T}\,/\,N\right)^{2}}$$

It is important to note that the variance of R is obtained by substituting the sample variances and co-variances for the population estimates.

Results

A composite table of dogfish discard estimates and variances are summarized by primary species groups for trawl, gill net and hook gear groups for 1989 to 2002 in Table 4.9. The discard estimates are based on a fishing year, defined as May 1 to April 30. Hence, the sampling in January-April 1989 sea sampling trips are labeled as the 1988 fishing year. Sampling frequency for hook gear was very low but this gear group was considered important for contemporary fishing practices under the federal and ASMFC management plans. Of the 13,637 trips analyzed, over 80% of the observer trips were on vessels using gillnets. Since 2000, the number of trips on trawling vessel has increased, with the number of trips exceeding 250 in each year. It should be noted that all of the standard MADMF observer trips are recorded in the NMFS observer database. Ancillary sea-sampling trips (~20 trips) conducted by MADMF in 2000 and 2002 on targeted dogfish trips will be summarized and compared with the current estimates in a later report.

Total discard estimates by year ranged from a high of nearly 90,000 mt in 1989 and 1990. The large estimates are driven by a limited number of trips in the trawl fishery. For example, the55,000 mt estimate in the 1988 fishing year is based on one trawl trip in which mackerel were the primary species. Estimates of dogfish discards in later years consistently had discard rates an order of magnitude less, even though the number of trips per year approached 15 in many years (Table 4.9). Similarly high rates were observed in a few scup-sea bass group trips in 1990 (36,016 mt) and squid-butterfish trips in 1991 (29,532 mt). In both instances, the CV of the estimate exceeded 75%, suggesting that the numbers were highly imprecise. In contrast, the results from 1992 onward suggested much more stable estimates, with relatively few outliers.

To avoid complications of arbitrarily deleting species groups across years, a consistent set of species group was used to generate annual estimates of discard rates by year and gear category (Table 4.10). After 1993 the discard estimates decline steadily, and the variance of the estimates decreases as well (Figure 4.15, top panel). By coincidence, the estimated discards for 1993 fishing year of 24,188 mt agrees well with an alternative estimator summarized in NEFSC (1994) and published in Rago et. al (1998). In general, the coefficients of variation for the annual totals were on the order of 25%. Higher CV values were typically associated with large discard estimates in the trawl fishery. Standard errors of the total discard estimates were generally proportional to the total discard estimate for all species groups for both trawls and gill nets (Figure 4.16). The projected number of dead discards was estimated by multiplying the discards in each gear group by an assumed level of discard mortality (Table 4.11). Discards mortality rates in the gill net, trawl, and hook gear categories were 0.75, 0.5 and 0.25, respectively.

As noted above, an analogous set of computations were conducted using a trip-based ratio estimator (Table 4.12). Although the numbers will not be used in the assessment, the numbers for the sum of the trawl and gill net gear groups agree well with the rates derived from the catch based estimator (Fig. 4.15, 4.17). The number of trips by gear groups is very large (Table 4.13) implying large expansion factors. Together with the indeterminacy of what constitutes a standard “trip”, additional work is necessary before such estimates could be useful for assessments.

5.0 FISHERY-INDEPENDENT DATA

5.1 Research Vessel Abundance Indices

5.1.1 NEFSC surveys

The Northeast Fisheries Science Center (NEFSC) has conducted both spring and autumn trawl surveys of the USA continental shelf annually since 1968. The surveys extend from the Gulf of Maine to Cape Hatteras. Details on the stratified random survey design and biological sampling methodology may be found in Grosslein (1969), Azarovitz (1981) and NEFSC (1995). Sex of spiny dogfish was not entered into the database until 1980.

Indices of relative stock biomass and abundance for spiny dogfish were calculated from NEFSC spring and autumn bottom trawl survey data. Overall indices were determined using only the offshore strata (1-30, 33-40, and 61-76) in order to obtain longer time series (i.e., 1967-1993 for the autumn survey and 1968-1994 for the spring survey). The autumn survey could not be extended back to 1963 because sampling of the Mid-Atlantic strata (61-76) did not begin until 1967.

In both the spring and the autumn surveys, there was considerable variability in the indices (Table 5.1 ,5.2, Figure 5.1). Both sets of indices indicate an overall increase in abundance and biomass from the early 1970s through the early 90s. Since that time, total index biomass has begun to decline, with greatest change occurring with females in the spring survey. The rate of change in the autumn survey has generally been less than observed for spring. At SARC 18 it was determined that the higher variability in the fall survey is attributable to variable fraction of the population present in Canadian waters during the NEFSC fall survey. The NEFSC winter survey utilizes a flat net without the large rock-hopper rollers present on Yankee 36 trawl used in the spring survey. Average catches in the winter survey are generally 3 to 5 times greater than the other NEFSC surveys (Table 5.3) Overall catches exhibit a slight downward trend but higher average catch rates are typically associated with higher SE of the estimates. An analysis of the relationship between the standard deviation of stratum estimates and its mean (Figure 5.2) illustrates the strong association linear relation between the SD and mean of each stratum. The proportionality suggests that a log transformed catch rate might lead to more stable estimates, although an initial examination of this relationship for the spring survey (Figure 5.3) revealed comparable levels of interannual variation.

5.1.2 State surveys

Abundance indices for spiny dogfish from Massachusetts spring and autumn inshore bottom trawl surveys in 1978-2002 reveal two different facets of dogfish abundance. The spring survey usually occurs before the major influx of dogfish to Massachusetts waters. Catches are low but variable. In the fall, catches tend to be an order of magnitude larger, as much of the dogfish stock is concentrated near the Massachusetts coast (Table 5.4, 5.5, Figure 5.4). Wide variations in availability results in highly variable survey indices. High variability in this survey is also a reflection of the seasonal use by dogfish of the area surveyed by the State of Massachusetts.

5.1.3 Canadian surveys

Indices of relative abundance for 1970-1993 from the Canadian summer bottom trawl survey conducted in NAFO Divisions 4VWX (Campana, pers. comm.) are depicted graphically in Figure 5.5. Overall dogfish abundance increased along with the rise the US spring survey. In contrast to the US surveys, male dogfish are more abundant than females. Additional work is necessary to understand differences between abundance patterns in US and Canada surveys.

5.2 Size and Sex Compositions

Size frequency distributions of spiny dogfish (sexes combined) from the spring and autumn NEFSC surveys were examined (Figure 5.6 a-d). The spring survey length frequencies have three modes corresponding to new recruits ($\leq$40 cm), mature males (70-80 cm), and mature females 95 cm. Large numbers of recruits have appeared periodically in the time series, especially in the early 1970s. The length frequency patterns in the autumn survey catches are much less consistent and there is no apparent tracking of modal lengths over time. Since 1997 both the spring and fall surveys are characterized by a single mode (Figure 5.6d).

Male and female size frequencies distributions are summarized by year for the spring (Figure 5.7 a-c) and fall surveys (Figure 5.8a-c). Male length frequencies are strongly skewed with an accumulation near the asymptotic size limit.

Qualitatively similar size frequency patterns for both sexes combined can be seen in the Massachusetts survey data (Figure 5.9 a-c) autumn survey.

Further insight into the changes in abundance and size composition may be obtained by examining the averaging size frequency compositions over multi-year periods (Figure 5.10). Three stanzas are considered. The first, 1985-88, illustrates the expected female size composition in a stable population. A large number of adults greater than 80 cm are present with a peak near the asymptotic size. Concomitantly, a relatively large number of juveniles less than 35 cm are also present. The second stanza can be considered the state of the resource during the peak of the fishery, 1995-1997. The numbers of adults has declined substantially and pups are much less abundant. Finally, the most recent stanza, 2001-2003, illustrates the cumulative effects of reductions in the spawning stocks and the near absence of pups in the surveys in the last 7 years. The reduction in abundance of the dogfish in the 50-60 cm range provides support for the hypothesis that the absence of recruits beginning in 1997 is real, since dogfish in this size range are expected to be about 4-7 years old. Changes in the total biomass at length (Figure 5.10 lower) illustrate the progressive removal of spawning stock over the three stanzas.

6.0 ANALYSIS OF INDEX TRENDS

In this section we further examine the changes in the survey indices and consider changes in swept area biomass for various size groups by sex. We then consider changes in the average size of mature females, the average size of pups, and demonstrate the relationship among maternal size, numbers of pups and average size of pups.

6.1 Swept-Area Biomass Estimates

Estimates of minimum stock biomass were determined from the NEFSC spring survey catches. Mean numbers per tow by sex and 1-cm length class were converted to average weights using a length-weight regression (females: $W = \exp(-15.0251) * L^{3.606935}$; males: $W = \exp(-13.002) * L^{3.097787}$). These average weights were then multiplied by the total survey area (64,207 n mi^2) and divided by the average area swept by a 30-minute trawl haul (0.01 n mi^2). Three size categories were defined ($\leq$35 cm, 36-79 cm, and $\geq$80 cm) which approximately correspond to new recruits, males and immature females, and mature females, respectively (Table 6.1).

One of the critical assumptions of the swept area computation is the size of the trawl footprint. The nominal footprint is based on the area swept by the net traveling at an average speed of 3.5 knots for 30 minutes. The effective capture zone is the distance between the wings of the net. Recent information (unpublished net mensuration data, Survey Branch, NEFSC) on variations in vessel speed and the increased contact time during haulback suggest that the effective area swept is greater than the nominal footprint. Additional details on this are provided in section 7. To illustrate the effect of this factor, the swept area biomass estimates are also computed with a nominal footprint of 0.012 n mi^2 (Table 6.2).

Swept area biomass estimates, using the 0.012 n mi^2 footprint were partitioned into size groups <36 cm, 36-79 cm, and $\geq$80 cm. For females, these size ranges roughly correspond to dogfish less than one year old, immature individuals and mature adults, respectively. For males, the intermediate size range represents both adolescent and mature individuals. Male dogfish >80 cm are mature, but relatively uncommon, as the average asymptotic size is about 80 cm.

Swept-area estimates of stock biomass exhibit annual variation that exceeds biologically realistic changes for such a long-lived species. Therefore, LOWESS smoothed (tension=0.5) estimates of biomass were considered to be better measures of population trends. Overall biomass estimates increased steadily from 1968 through 1992 to about 600 k mt, but have declined to about 400 k mt, about the same level as observed in 1985 (Figure 6.1). The changes in total biomass mask significant changes that have occurred within size and sex groups. Most of the change since 1992 has occurred in the 80+ cm male and female spawners stock where abundance has declined from about 250 k mt to about 50 k mt in 2003 (Figure 6.2, top). The pool of male and female dogfish between 36 and 79 cm has remained relatively stable over the past decade (Figure 6.2, bottom) at about 350 k mt. From 1980 onward, dogfish sex was recorded in the NEFSC database, allowing examination of the trends by sex as well. Figure 6.3 reveals the marked change in female spawner biomass (top) and evidence of reductions in the large males as well (bottom). Biomass changes in the intermediate size range of females are now evident (Figure 6.4, top) as the fishery has continued to accept smaller sized dogfish. No change is apparent in male 36-79 cm dogfish since the early 1990's (Figure 6.4, bottom).

The biomass of dogfish less than 36 cm represents individuals less than one year old at the time of the survey and are considered recruits to the population. Recruitment generally has been stable through most of the time series with a number of strong year classes in the 1980's (Figure 6.5). The numbers of recruits in the last 7 years, however, are the 7 lowest in the 36 year series. Coincident with the change in abundance, the average size of dogfish in this size range has also declined about 3 cm (Figure 6.6). The trend in abundance of recruits is consistent with the reduction in spawning stock, but the magnitude of the change is unexpected. In the following sections we explore possible reasons for the decline in pup abundance and introduce new biological information on dogfish reproduction.

6.2 Changes in Mean Size of Mature Females

In recent years, considerable attention has been paid to the impacts of demographic variation on reproductive output (Murawski et al. 2001). In general evidence for many fish populations suggests lower reproductive output from younger spawners, and these differences are greater than simple reductions in number of eggs produced. To examine the reduction in average size of mature female dogfish, the average length of mature dogfish (80+ cm) was computed for the NEFSC fall (1980-2002), winter (1992-2003), and spring (1980-2003) surveys, the MADMF spring (1980-2002) and fall (1980-2002) surveys, and the NC SeaMap (1997-2003) surveys. The trends in average size of mature females show a remarkable consistency across all surveys (Fig. 6.7). Average size has declined from about

95 cm to 85 cm over this period, with consistent rates of change among surveys . Even the much shorter time series of the NC SeaMap survey shows a size range of mature dogfish consistent with the observations of the 5 other surveys (Figure 6.8). From these data, there is no evidence that a population of large-sized females is present in the Northeast US. The Canadian summer survey typically captures a much smaller sized female than the US surveys (S. Campana, DFO, per comm.). Additional analyses of Canadian data are warranted.

6.3 Potential Reasons for Reduced Pup Production 1997-2003

6.3.1 Fecundity and Pup Size in Relation to Maternal Size

In 1997 the SARC 26 noted the first year of low pup production and commented that it may be related to the reduction in spawning stock. A substantial amount of additional information on the reproductive biology of dogfish has been collected since the last assessment. Here we provide additional information on the factors that may underlie these changes in dogfish abundance.

Spiny dogfish females 65 cm or greater in total length (10 cm below the previously estimated size at first maturity) were examined during the bottom trawl surveys conducted by the NEFSC from 1998-2002. The trawl surveys are conducted in three seasons: winter (February), spring (March-April), and autumn (September-October) (Azarovitz 1982). The spring and autumn surveys cover the region from Cape Hatteras, NC, through the Gulf of Maine. The winter survey covers the region from Cape Hatteras, NC, to Georges Bank. A summary of the sampling by year and survey in provided in Table 6.3.

Each female was examined for the presence of free embryos, fertilized uterine eggs (candled embryos), and ovarian eggs. Immature females were classified as those with small ovaries containing either no eggs or small, non-developing eggs. A female was determined to be mature if large, well-developed eggs were present in the ovaries or if embryos were present in the uterus. If free embryos were present and time permitted, the embryos were counted for fecundity analysis. Candled embryos and ovarian eggs were not used in the fecundity analyses because they were prone to rupture.

The relationships between pup weight and average pup weight with maternal length (Figure 6.9) show a consistent increase with maternal length. All of the data in Figure 6.9 represent near-term free embryos at least 18 months old. A 100-cm female produces a pup that is 5 cm longer and about 50% heavier than an 80 cm female. The number of pups produced also increased with maternal length (Figure 6.10, top) but females with more than 6 pups were uncommon for dogfish less than 95 cm. The number of fertilized eggs and free embryos did not appear to change with gestational month (Figure 6.10 bottom). Such changes might be expected if capture stress or other factors were decreasing the number of fertilized eggs within the females. Larger numbers of near-term free embryos also corresponded to larger average sizes (Figure 6.11). Thus, larger females produce larger clutches of eggs and larger average-sized pups. Collectively, these factors suggest, but do not confirm, that larger females produce a more fit offspring, potentially subject to a smaller spectrum of predators.

A simple test of this hypothesis was conducted by examining the relationship between the predicted pup production from the spring survey and the observed numbers in the survey. Using a 3-yr average size composition of females, the predicted number of pups in year t was estimated at the sum product of the number at length and the average pups per 1-cm length group. The total pup production from this computation is multiplied by the first year survival rate (Section 8.0) = 0.68. No other statistical adjustments to the data were computed. The relationship between the observed and predicted numbers of pups (Figure 6.12) reveals good agreement in terms of scale. Moreover, the differences between the observed and predicted pup production shows that predicted number of pups are consistently negative from 1997 onward. Thus, the number of pups actually produced are lower than expected even when accounting for the reduced abundance of mature females. Figure 6.13 provides additional support for this hypothesis, showing the decrease in numbers and average size of mature females (top) and the clustering of negative residuals by year (bottom). These results suggest that population projections that rely on a constant first year survival rate (Section 9.0) may be overly optimistic with respect to population recovery.

7.0 Fishing Mortality and Biomass Estimation

7.1 Beverton-Holt Estimator

Instantaneous total mortality rates (Z) for female dogfish were estimated using the length based method of Beverton and Holt (1956)

$$Z = \frac{K(L_{\infty} - \overline{L})}{\overline{L} - L'}$$

where K and L∞ are from the von Bertalanffy growth model and L is the stratified mean length of individuals in the spring survey greater than the critical length L'. L' is the 25%-ile of length in the commercial landings. Parameters for female were K=0.1128, Lmax=105 cm. Fishing mortality rate is obtained at the difference between Z and natural mortality M. The Beverton-Holt estimator was evaluated over a range of sizes at entry to the fishery and natural mortality rates (M=0.092; 50-yr lifespan, M=0.06; 100-yr lifespan) to explore the sensitivity to these assumptions.

Mortality rates averaged about 0.06 during 1980's when landings averaged about 6,000 mt. Landings nearly tripled between 1989 and 1990, increased since then to over 28,000 mt in 1997 and have subsequently decreased (Table 4.1). The increase in fishing mortality rates reflects the increase in landings to levels above 0.4 in the late 1990's. Regardless of the underlying parameter assumptions, the estimates of F exceed the biological reference points of 0.08 (target) and 0.11 (threshold) (Figures 7.1, 7.2). The Beverton-Holt estimator is expected to lag the true rate of fishing mortality when fishing mortality is increasing. Conversely, since it is dependent on the growth and assumes an equilibrium size structure, it is subject to transient conditions. Thus, the mortality estimates for the female population in the last 3 years, when fishing mortality rates have declined, are likely to reflect the history of the fishery rather than the contemporary status. During the course of various meetings related to the development of the federal and ASMFC management plans, it was noted that additional analyses would be required to assess contemporary fishing mortality rates. Those analyses are presented below.

7.2. Selectivity of Fishery

The changes in average size of dogfish are consistent with the targeted removal of large females. However, the changes in size selectivity over time also have important implications for the total force of fishing mortality on the population. High rates of mortality over a broad range of size groups have greater biological implications than an equivalent fishing mortality rate over a narrow range of size classes. The magnitude of these changes is important for estimation of fishing mortality, for evaluation of reference points and for population projections under various management scenarios. The first step in developing an estimator of F which incorporates both landings and survey information is to estimate a size specific selectivity function.

The selectivity of the fishery was approximated by assuming that proportion of stock available to the commercial fishery could be expressed as a logistic function of the size frequency distribution of the survey. Let $p_s(\ell)$ represent the proportion at length ℓ in the survey and let $p_c(\ell)$ represent the proportion at length ℓ in the commercial landings. The statistical model to relate these quantities can be written as

$$p_c(\ell) = \frac{p_s(\ell)\left(\dfrac{1}{1+e^{a+b\ell}}\right)}{\sum_{\ell=50}^{L_\infty} p_s(\ell)\left(\dfrac{1}{1+e^{a+b\ell}}\right)}$$

where a and b represent the parameters to be estimated. In general this model fit the data very well. Details on the application of this model to data from 1990-2002 by sex are provided in Appendix 1.

Additional data on the size selectivity of the dogfish fishery are can be obtained by examining detailed discard size composition data provided by the Massachusetts Division of Marine Fisheries for 2000-2002. The fraction retained by size interval was fit to a logistic function by year (Fig. 4.18). Model results suggest that the median size of retained dogfish in Massachusetts fisheries declined from 77 cm in 2000 to 70 cm in 2001 and further decreased to 65 cm in 2002.

7.3 Stochastic Estimation of Fishing Mortality and Biomass

7.3.1 Methods

A stochastic estimator of fishing mortality was developed to improve the estimation of contemporary estimates of fishing mortality. The estimator developed below incorporates a greater degree of mechanistic detail and uncertainty in the data. Several different measures of fishing mortality are of interest. First, we are interested in the total rate of mortality on the exploitable stock of male and female dogfish(F_1). Second, we are interested in the mortality generated by the removals of discards (F_2). This quantity is differentiated from F_1 because it acts non selectively over the entire stock, not just the exploitable stock. The weighted average of F_1 and F_2, called F_{bar}, represents the force of mortality acting on the entire stock. (In VPA speak, this is the biomass-weighted F). In terms of evaluating the fishing mortality rate with respect to a biological reference point, we are interested in a metric commensurate with the pup-per-recruit analyses (Section 8.0).

Define

F_1 = F generated by total landings acting on the exploitable biomass of male and female dogfish
F_2 = F generated by total discards plus recreational catch, acting on the total biomass of male and female dogfish.

F_{bar}= Biomass-weighted average F derived from F1and F2

F_3 = Fishing mortality rate on female dogfish, estimated as the ratio of female dogfish landings divided by exploitable biomass of female dogfish

F_4 = Fishing mortality rate on male dogfish, estimated as the ratio of male dogfish landings divided by exploitable biomass of male dogfish

Using the catch equation, it is possible to define the various F metrics as follows

Variable Definitions

L = Total landings(mt) of USA plus Canadian commercial landings
L_f = Landings(mt) of female dogfish in USA plus Canadian commercial landings
L_m = Landings(mt) of male dogfish in USA plus Canadian commercial landings

$B(\ell)$ = Total biomass(mt) of male plus female dogfish at length ℓ.
$B_f(\ell)$ = Total biomass(mt) of female dogfish at length ℓ.
$B_m(\ell)$ = Total biomass(mt) of male dogfish at length ℓ.
$B(\ell)=B_f(\ell) + B_m(\ell)$

$B_{expl}(\ell)$ =Exploitable biomass(mt) of male plus female dogfish at length ℓ.
$B_{fxpl,f}(\ell)$ = Exploitable biomass(mt) of female dogfish at length ℓ.

$B_{expl,m}(\ell)$ = Exploitable biomass(mt) of male dogfish at length ℓ.
$B_{expl}(\ell)=B_{expl,f}(\ell) + B_{expl,m}(\ell)$

D = Total discards (mt)
$N(\ell)$ = Number of dogfish in population at length ℓ.
$I(\ell)$ = Index number of dogfish in population at length ℓ.
$p(\ell)$= proportion of dogfish in population of length class ℓ

$sel_f(\ell)$ = Selectivity fraction for females of length ℓ.
$sel_m(\ell)$ = Selectivity fraction for males of length ℓ.

$W_f(\ell)$ = Average weight (kg) of females of length ℓ.
$W_m(\ell)$ = Average weight (kg) of males of length ℓ.

A= Total domain of offshore survey strata (nm^2)
a= Area swept by standard trawl tow (nm^2).

Xbar,t = Average number of dogfish caught per tow in NMFS spring survey in year t.
S^2_t = Estimated variance of mean catch per tow in NMFS spring survey in year t.

$$L_f + L_m = \sum_{l=l_{\min}}^{l_{\max}} F_1\left(sel_f(l)B_f(l) + sel_f(l)B_f(l)\right)$$

$$D = \sum_{l=l_{\min}}^{l_{\max}} F_2 B(l)$$

$$L_m + L_f + D = \sum_{l=l_{\min}}^{l_{\max}} F_{bar} B(l)$$

$$L_f = \sum_{l=l_{\min}}^{l_{\max}} F_3 sel_f(l) B_f(l)$$

$$L_m = \sum_{l=l_{\min}}^{l_{\max}} F_4 sel_f(l) B_m(l)$$

The estimates of F can be obtained by rearranging Eq. 1 to 5 , simply dividing the left hand side by the non-F terms on the right hand side equation.

The biomass variables can be written as the product of survey numbers at length and average weight at length and a scaling factor equal to the ratio of the total survey area divided by the footprint of the average tow.

$$
\begin{aligned}
&B(l) = B_f(l) + B_m(l) \\
&where, \\
&B_f(l) = N_f(l)W(l) = I_f(l)\left(\frac{A}{a}\right)W_f(l) \\
&B_m(l) = N_m(l)W(l) = I_m(l)\left(\frac{A}{a}\right)W_m(l)
\end{aligned}
$$

The index number at length by sex can be further generalized to express it as the average number per tow, X_{bar}, times the fraction of the population at length p(ℓ). The proportion at length is derived from the survey.

$$
\begin{aligned}
I_f(l) &= \overline{X}_f p(l) \\
I_m(l) &= \overline{X}_m p(l)
\end{aligned}
$$

All of the quantities in Eq.1 to 5 are measured with error but, for this assessment, it is assumed that the errors in the estimates of landings by sex and length class are negligible. Much greater variation is likely for survey abundance measures and total discards. To capture the effects of these sources of variation, stochastic versions of Eq. 1 to 5 were computed by convolving distributions of survey abundance, discards and trawl footprints.

Substantial variation in survey based estimates of dogfish abundance occurs across years. For some years, the variation exceeds what would be expected in terms of possible biological changes. To accommodate such variation, we use a simple 3 yr moving average smooth of the overall abundance estimates. The composite averages by sex are estimated as

$$
\begin{aligned}
\overline{\overline{X}}_{f,t} &= \frac{\sum_{j=t-1}^{j=t+1} \overline{X}_{f,j}}{3} \\
\overline{\overline{X}}_{m,t} &= \frac{\sum_{j=t-1}^{j=t+1} \overline{X}_{m,j}}{3}
\end{aligned}
$$

The associated variances are estimated as

$$\bar{S}^2_{f,t} = \frac{\sum_{j=t-1}^{j=t+1} \bar{S}^2_{f,j}}{3}$$

$$\bar{S}^2_{m,t} = \frac{\sum_{j=t-1}^{j=t+1} \bar{S}^2_{m,j}}{3}$$

Sampling theory suggests that the survey mean should be asymptotically normal. We exploit this feature to simplify the estimation of the stochastic distribution of the Fs.

A summary of the 3-yr moving average and its composite variation is provided in Table 7.1.

The survey footprint is also measured with error. One source of error is the magnitude of variation in the length of the tow. The effective time on the bottom can exceed the nominal tow duration owing to delays in lifting the net off the bottom during haulback. As the net is moving forward with the combined forward velocity of the vessel plus the forward speed of the cable, the effective area swept will exceed the nominal target. To account for this variation in footprint size, preliminary data collected aboard the R/V Albatross IV in 2002 were used to estimate the possible variation in tow lengths (See Table 7.2).

Variation in discards was estimated using the method described in Section 4.4.

Evaluation Method

Let Φ = Normal cumulative distribution function. The inverse of Φ, denoted as Φ^{-1} allows the evaluation of a set of values over a specified range, say α_{min} and α_{max}, over equal probability intervals.

$$X'_{t,\alpha} = \Phi^{-1}(\alpha \mid \bar{\bar{X}}, \bar{S}^2_t)$$

The step size between successive values of α was set as 1/500 (0.975-0.025), where α_{min} =0.025 and α_{max}.=0.975. An equivalent approach was used for evaluation of the footprint parameter a where a~N(μ_a , σ_a^2) and the discard estimate D~N(μ_D , σ_D^2). For both of these parameters the sample mean and variance estimates were used to estimate the normal distribution parameters.

The sampling distribution of each of the Fs described above was evaluated by integrating over each of the normal distributions for X, a, and D. As each parameter was evaluated over 500 equal probability intervals, there is reasonable assurance that the sampling distributions of the Fs will be appropriately estimated. The computer program for evaluating the distributions of F is provided in Appendix 2.

7.3.2 Results

Biomass Estimates
Stochastic estimates of exploitable biomass, total biomass and spawning stock biomass are summarized in Table 7.3 (minimum footprint assumption) and Table 7.4 (maximum footprint assumption) for 1990 to 2002. Trends in total biomass and SSB biomass are comparable to results presented in Tables 6.1-6.2. Incorporation of the uncertainty in the survey mean numbers per tow and footprint variation (within the two alternatives, i.e., min versus max footprint) suggests relatively precise estimates. The exploitable biomass quantities vary as a function of the selectivity functions derived in Section 7.2. These quantities are more erratic as they reflect the joint action of a temporally varying selectivity pattern and changes in underlying total biomass. The derived sampling distributions of the various biomass estimates are depicted graphically in Figures 7.3 to 7.6. As the selectivity of the fishery shifted toward smaller individuals the distributions of total and exploitable biomass exhibited a greater degree of overlap (Figures 7.3 and 7.5). The decline in SSB between 1990 and 2002 is evident in Figures 7.4 and 7.6, and notably, the reduced variation is also evident. By 2002, the stochastic SSB estimates were coincident with the exploitable biomass estimates. This suggests that the fishery is selecting individuals over the entire range of sizes within the exploitable stock.

Fishing Mortality Estimates
Stochastic estimates of F attributable to removals, the total exploitable biomass, discards, and exploitable biomass by sex are summarized in Table 7.5 (minimum footprint assumption) and Table 7.6 (maximum footprint assumption) for 1990 to 2002. The fishing mortality on the total biomass peaked in 1996 at 0.09 and has decreased since then to about 0.03 (Table 7.5). Under the assumption of the maximum footprint, the fishing mortality on total biomass is on the order of 0.07 (Table 7.6). Discard mortality, as it acts over the entire population, has generally been low, ranging under 0.03 over the last 10 years (Table 7.5). For the maximum footprint assumption, the discard F has generally been less than 0.06 (Table 7.6).

From the standpoint of the stock assessment, the most relevant quantity is the fishing mortality rate on the exploitable female biomass. As noted above, this quantity is now equivalent to the total spawning stock. The fishing mortality rate on the exploitable stock is denoted as F3 in Tables 7.5 and 7.6. Under the assumption of the minimum footprint, the F on the exploitable female biomass is 0.094. Note that the fishing mortality biological reference points are 0.08 for the target and 0.11 for the threshold . Note also that the target F for rebuilding of the stock is intended to be 0.03. The implications of these rates of fishing mortality for population recovery are treated more fully in Section 9.

The derived empirical distributions of F estimates on the exploitable biomass by sex and the discard mortality rate are shown in Figures 7.7 (min footprint) and 7.8 (max footprint). Despite the wide variation in the range of discard estimates, the overall rate remains relatively low except in the early 1990s. The distribution of F on females has been greatly reduced by the management measures in the US but these have been offset by concomitant increases in landings in Canada.

Comparison with Beverton-Holt Estimates

An overall comparison of the stochastic mean estimates of F on the exploitable female population and the Beverton-Holt estimates is provided in Figure 7.9. The range of stochastic Fs derived under the alternative footprint values generally envelope the quantities derived from the BH estimates. The lack of agreement is greatest in the last 3 years, consistent with the hypothesis that the BH estimator would be more strongly influenced by the transient population condition. It is also interesting to note the substantial degree of agreement among the estimates during the period when the fishery was growing rapidly through the mid 1990s.

8.0. Life History Model

The life history model used to estimate biological F reference points for spiny dogfish are summarized in Rago et al. (1998) and in SARC 26. No additional work on this particular aspect of the assessment has been conducted.

The application of the Ricker stock-recruitment relationship to spiny dogfish was reviewed jointly by the New England and Mid-Atlantic Fishery Management Councils' Statistical and Scientific Committees in 1999. On the basis of these meetings, an estimate of the SSB necessary to produce the maximum recruitment, denoted as SSB_{max} , was set at 200,000 mt. It should be noted that the estimate of 200,000 mt "roughly" corresponds to a swept area biomass estimate based on a nominal trawl footprint of 0.01 nm^2. The modifier "roughly" is used because the estimate was taken from a graph of the Ricker function plot. The stock and recruitment data for spiny dogfish are summarized in Table 8.1. The actual point estimate corresponding to the peak value of the Ricker function for the 1968-1996 data is 215,024 mt. The data used in this relationship were two year averages of recruitment, and SSB.

It is important to note that the estimate of SSB_{max} scales directly with the NEFSC spring research trawl survey. The abundance index, in kg/tow, for female dogfish greater than 80 cm is converted to total biomass by multiplying the average by the ratio of the total survey area (~64,207 nm^2) and the footprint of the trawl. Evidence presented in section 6.3 suggests that the actual footprint exceeds the nominal footprint of 0.01 nm^2 by about 10 to 20%. More specifically, since SARC 26, updated information on vessel speed and contact time suggested that the average footprint corresponded to a contact time of 33 minutes (rather than 30) and a vessel speed of 3.8 knots (rather than 3.5). These changes increase the nominal footprint to 0.012206 nm^2 or about 20% greater than the nominal footprint. Increasing the footprint reduces the swept area biomass estimate, leading to an alternative estimate of the SSB_{max} of 167,000 (i.e., 200,000 mt *(0.01/0.12)=166,667 mt).

The important conclusion from this example is that the trawl footprint simply scales the abundance index for both recruitment and SSB. The underlying relationship between recruits and SSB is unaffected, such that estimates can be derived from analyses of the survey data alone (recruits expressed in numbers per tow, SSB expressed in kg/tow). The results of alternative model formulations are summarized in Table 8.2. The estimate of SSB_{max} of 214,024 mt corresponds to an average weight per tow of 33.2 kg. If unsmoothed data, rather than a 2 point moving average, are used, the estimate of SSB_{max} becomes 35.9 kg, but its variance increases significantly.

Inclusion of the data from 1997 to 2003 illustrates another important property of the SSB_{max} estimate. Recruitments since 1997 represent the seven lowest values in the 1968-2003 time series. Incorporation of these values into the Ricker model estimate has no effect on the R_{max} estimate, but the estimate of SSB_{max} increases by 37% to 294,000 mt (Table 8.2). A Lowess smooth of the SR data (Fig. 8.1) is much less sensitive to the additional years of data with an approximate SSBmax slightly less than 200,000 mt (using the $0.01nm^2$ footprint). Discussion of the scaling problems at the SARC led to the general recommendation that the smoothed estimate for the entire data series would be a more appropriate measure of SSB_{max}, if an empirical model of the SR function were used to provide a biomass reference point.

The Ricker model assumes that the total female biomass is an adequate measure of spawning potential. As described in Section 6.3, the reproductive output of dogfish declines with maternal size with decreases in both numbers and size of pups. The information on decline in pup size in smaller females is an important conclusion in this assessment as it provides a possible explanatory mechanism for the lower than expected pup production since 1997. The SARC requested additional exploration of this mechanism, the results of which are summarized below.

An alternative measure of reproductive potential can be obtained considering the reproductive potential as a function of the maternal size distribution and numbers of pups per female at size. For this analysis, no smoothing of abundance indices was performed. Observed pups were computed as the sum of densities (number per tow) for all catches between 20 and 35 cm. Predicted pups were computed as product of mature female densities at length, predicted numbers of pups per length class and estimated survival rate. The estimated survival rate is computed under two models: a) no maternal effect, b) survival as function of maternal length. Under model (a) the survival function is estimated as $S_o(L)= 1/(1+\exp(0.5389))=0.368$ with a MSE of 0.234 and $R^2=0.456$ (Fig. 8.2). Under model (b) wherein maternal size is assumed to affect pup survival, the resulting function $S_o(L)= 1/(1+\exp(28.123-0.305*L))$ reduces MSE to 0.196 and increases R^2 to 0.564. Both of these models appear to be superior to the Ricker SR model for predicting recruitment. The limitation of the demographic model is that it does not provide a simple method for defining the optimum level of SSB corresponding to R_{max}. Instead, the demographic model is unbounded with respect to SSB_{max}. The results of the demographic recruitment model are incorporated into the stochastic projection scenarios in the following section.

9.0 Stochastic projection model

9.1 Overview

A length-based stochastic projection model was developed to evaluate effects of alternative fishing mortality scenarios. The model incorporates sex specific rates of growth and fishing mortality. Discard mortality is assumed to act equally all size ranges of both sexes.

Reproduction in the model is assumed to be proportional to stock abundance. The basic model can be written in terms of two matrix equations as

$$N_{f,t+1} = S_{f,Z,t}P_f S_{D,t}N_{f,t} + S_{D,t}N_{f,t}^T Pup\, S_o \varphi R_f^o$$

$$N_{m,t+1} = S_{m,Z,t}P_m S_{D,t}N_{m,t} + S_{D,t}N_{f,t}^T Pup\, S_o (1-\varphi) R_m^o$$

where

$\mathbf{N_{f,t}}$= Vector of female population abundance at length. Dimension = $(\ell_{max}- \ell_{min}+1)$

$\mathbf{N_{m,t}}$= Vector of male population abundance at length. Dimension = $(\ell_{max}- \ell_{min}+1)$

$\mathbf{S_{D,t}}$= Diagonal matrix of discard survival rates at time t. Dimensions = $(\ell_{max}- \ell_{min}+1, \ell_{max}- \ell_{min}+1)$

$\mathbf{S_{f,Z,t}}$=Diagonal matrix of composite survival from instantaneous fishing and natural mortality rates for females at time t. Dimensions = $(\ell_{max}- \ell_{min}+1, \ell_{max}- \ell_{min}+1)$

$\mathbf{S_{m,Z,t}}$=Diagonal matrix of composite survival from instantaneous fishing and natural mortality rates for males at time t. Dimensions = $(\ell_{max}- \ell_{min}+1, \ell_{max}- \ell_{min}+1)$

$\mathbf{R^o}$=Vector of proportions at length of new recruits. Dimension = $(\ell_{max}- \ell_{min}+1)$

$\mathbf{P_f}$= Growth projection matrix for females. Dimensions = $(\ell_{max}- \ell_{min}+1, \ell_{max}- \ell_{min}+1)$

$\mathbf{P_m}$= Growth projection matrix for males. Dimensions = $(\ell_{max}- \ell_{min}+1, \ell_{max}- \ell_{min}+1)$

Pup= Vector of length specific pup production rates for mature females. Dimension = $(\ell_{max}- \ell_{min}+1)$

$\mathbf{S_o}$= Scalar first year survival rate of newborn pups. Derived from analysis of life history model

T = Transpose operator

$\boldsymbol{\varphi}$ = proportion of female pups at birth; 0.5 implies an equal sex ratio.

Note that the projection equation for males is a function of the numbers of recruits. produced by females.

Notation Footnote
Vector quantities and operations will be denoted in bold font. As examples, let **X** denote a matrix with k x k elements, and **Y** denote a vector with k elements. Then **XY** would define the matrix multiplication of the vector **Y** by matrix **X** yielding a vector quantity, say **Z**. Similarly, $\mathbf{Y}^{\mathbf{T}}\mathbf{Y}$, read as **Y** *transpose* **Y,** represents the dot product of the elements of **Y** with itself, yielding a scalar quantity. Scalar multiplication of a vector is denoted as c**Y** where c is an arbitrary constant. By convention, matrix operators proceed from left to right and in general, operations are not commutable.

The elements of a matrix are denoted by appending the appropriate number of identifiers within parentheses following the variable name. Thus, X(i,j) represents the scalar quantity in the i^{th} row and j^{th} column of the matrix **X** and Y(i) represents the i^{th} element of the vector **Y**.

The component processes of the matrix model and quantities derived from the population states are described below. The Fortran computer code used to implement the model is provided in Appendix 3.

9.2 Processes

9.2.1 Growth

Growth in length at age is modeled by the von Bertalanffy equation applied separately to each sex. The model parameters are taken from Nammack et al. (1985). The projection matrices, $\mathbf{P_f}$ and $\mathbf{P_m}$ for females and males, respectively, are defined as square matrices consisting of 0, 1 elements. The non-zero elements in cell i, j indicate the growth of individuals from cell i to cell j. The growth of individual dogfish from length i to length j is modeled by first inverting the von Bertalanffy equation to obtain the age of individuals of length i to obtain age i. The projected length at age_{i+1} is then obtained substituting age_{i+1} back into the von Bertalanffy equation to obtain length j. The projection matrix algorithm for females can be summarized as follows:

$$Step\ 1.\ Find\ age\ for\ L_i$$

$$a_{f,i} = \frac{\log\left(1 - \frac{L_{f,i}}{L_{f,\infty}}\right)}{K_f} + t_{f,o}$$

$$Step\ 2.\ Compute\ L\ in\ next\ time\ step$$

$$L_{f,j} = L_{f,\infty}(1 - e^{-K_f(a_{f,i}+1-t_{f,o})})$$

$$Step\ 3.\quad Compute\ element\ of\ \ projection\ matrix$$

$$P_f(\text{int}(L_{f,j}), \text{int}(L_{f,i})) = 1$$

The same algorithm is defined for males by substituting the m for f in the subscript terms of the above equation.

9.2.2 Fishing and Natural Mortality

Natural mortality is assumed equal to 0.092 and to be constant over all length classes. Fishing mortality in year t, defined as F_t, is multiplied by sex-specific selectivity functions (Sec. 7) to estimate the sex- and length-specific fishing mortality rates. The diagonal matrices that decrement the populations for fishing and natural mortality are defined as $\mathbf{S_{f,Z,t}}$ and $\mathbf{S_{m,Z,t}}$ with elements defined by

$$S_{f,Z,t}(\ell,\ell) = e^{-(sel_f(\ell)F_t + M)}$$

$$S_{m,Z,t}(\ell,\ell) = e^{-(sel_m(\ell)F_t + M)}$$

In some scenarios it is desirable to evaluate the effects of a quota rather than a fishing mortality rate. For these scenarios it is necessary to iteratively solve for F_t sufficient to generate a quota of magnitude Q_t. A Newton-Ralphson algorithm (function rtsafe, p 359 in Press et al. 1992) was used to find the value of F. The application to this length-based model is patterned after the approach used in Brodziak et al. 1998. When a quota was too large for the estimated exploitable biomass to support, a default F=3.0 was set as an upper bound.

9.2.3 Discard Mortality

Instantaneous discard mortality rates for the entire population were estimated using methodology described in Section 7.. The discard matrix in Eq. 9.1 is a diagonal matrix with principal diagonal elements estimated as

$$S_{D,t}(\ell,\ell) = e^{F_{discard,t}}$$

For all scenarios considered in this report, the discard rate was set equal to the estimate for 2002 (i.e. $F_{discard}$ ~ 0. 02). Note that the discard rate is assumed to be equal for all length classes. In the model, it is assumed that discard acts as a Ricker Type I fishery in which the discard is assumed to occur before the fishing and natural mortality. This approximation results in a small overestimate of the numbers discarded. Assuming a discard rate of 0.02, the effect on discard numbers would be 4% higher when F=0 and 8% when F=0.11 when comparing a type I and II fishery.

The survivors after discard mortality has occurred is written as

$$N_{f,t+\Delta t} = S_{D,t} N_{f,t}$$
$$N_{m,t+\Delta t} = S_{D,t} N_{m,t}$$

The numbers of discards at length by sex, $\mathbf{D_{f,t}}$ and $\mathbf{D_{m,t}}$, for females and males, respectively, is defined as

$$D_{f,t} = N_{f,t} - N_{f,t+\Delta t}$$
$$D_{m,t} = N_{m,t} - N_{m,t+\Delta t}$$

9.2.4 Reproduction

The total number of pups produced is written at the product of the length-specific pup production rates and the number of females alive in year t.

$$Pup_{TOT,t} = S_o N^T_{f,t+\Delta t} Pup$$

The numbers of pups produced by length and size category is estimated by splitting the total pup number by sex and multiplying by the observed proportion of dogfish at length for a lengths assumed to be less than one year old at the time of the survey. The resulting numbers of pups produced is written as:

$$female\ pups = \varphi Pup_{TOT,t} R^o_f$$
$$male\ pups = (1-\varphi) Pup_{TOT,t} R^o_m$$

The $\mathbf{R_f}$ and $\mathbf{R_m}$ vectors representing the proportions by length class consist of (ℓ_{max}- ℓ_{min}+1) elements of which only elements 1 to k are non-zero. The male and female vectors have equivalent proportions but differ with respect to vector length, owing to the larger maximum size attained by females.

9.2.5 Biomass Outputs: Yield, Discards SSB, Exploitable Biomass, Total Biomass

Yield is estimated by applying the catch equation to the number of individuals alive after discarding has occurred. The catch at length by sex is estimated as

$$C_{f,t}(\ell)=\left(\frac{F_t sel_f(\ell)}{F_t sel_f(\ell)+M}\right)\left[1-e^{-\left(F_t sel_f(\ell)+M\right)}\right]N_{f,t+\Delta t}(\ell)$$

$$C_{m,t}(\ell)=\left(\frac{F_t sel_m(\ell)}{F_t sel_m(\ell)+M}\right)\left[1-e^{-\left(F_t sel_m(\ell)+M\right)}\right]N_{m,t+\Delta t}(\ell)$$

The total yield by sex is computed as the sum of the products of the numbers caught and their average weight . In matrix notation this is written as:

$$Y_{f,t} = C_{f,t}^T W_f$$
$$Y_{m,t} = C_{m,t}^T W_m$$
$$and$$
$$Y_t = Y_{f,t} + Y_{m,t}$$

Discards in weight, $D_{B,t}$ are estimated in a similar fashion such that:

$$D_{B,f,t} = D_{f,t}^T W_f$$
$$D_{B,m,t} = D_{m,t}^T W_m$$
$$and$$
$$D_{B,t} = D_{B,f,t} + D_{B,m,t}$$

The total biomass of the population by sex $B_{f,t}$ and $B_{m,t}$, is estimated as the total number alive at the start of the year multiplied by the average weight at length.

$$B_{f,t} = N_{f,t}^T W_f$$
$$B_{m,t} = N_{m,t}^T W_m$$
$$and$$
$$B_t = B_{f,t} + B_{m,t}$$

Exploitable biomass is defined as the fraction of the population biomass available to the fishery given the prevailing selectivity pattern. The commercial selectivity pattern by sex is defined in Section 7.2. Exploitable biomass will always be less than total biomass and is computed as follows:

$$B_{Expl,f,t} = \sum_{j=\ell_{\min}}^{\ell_{\max}} sel_f(j) N_{f,t}(j) W_f(j)$$

$$B_{Expl,m,t} = \sum_{j=\ell_{\min}}^{\ell_{\max}} sel_m(j) N_{m,t}(j) W_m(j)$$

and

$$B_{Expl,t} = B_{Expl,f,t} + B_{Expl,m,t}$$

Finally, the spawning stock biomass is expressed in terms of female biomass only and is defined at the sum of mature females. In the projection model, females are assumed to be mature at 80 cm such that the spawning stock biomass can be written as

$$SSB_t = \sum_{j=80}^{\ell_{\max}} N_{f,t}(j) W_f(j)$$

9.3 Initial conditions

The initial condition of the population was defined as the 3-yr average (2001-2003) of dogfish abundance in the NEFSC spring R/V trawl survey. Unlike the stochastic estimator of fishing mortality and biomass, the projection model does not incorporate uncertainty in the estimates of discard mortality or the footprint of the survey. Instead, the projection model incorporates the variation in abundance defined by survey abundance. Variation in mean abundance is used to scale the index numbers at length by generating values of mean abundance over 500 equally-spaced probability intervals.

Following the recommendation of the subcommittee, all projections were computed using the minimum footprint size. Use of the minimum footprint increases the biomass estimate and decreases the fishing mortality estimate, relative to the alternative maximum footprint.

9.4 Scenarios

A large number of scenarios are possible. Terms of Reference 4 through 6 requested

> *4) Estimate yield based on stock status and target mortality rate (F = 0.08) for fishing year 2004 (May, 2004 through April, 2005).*
>
> *5) Provide short term projections (2-3 years) of stock status under a variety of TAC/F strategies*
>
> *6) Evaluate existing and alternative rebuilding schedules based on current/projected stock status.*

Items 5 and 6 are closely related but indefinite. To help bound the problem, six projection scenarios were defined. Each was based on previously specified scenarios that have been previously analyzed in committee preparations for the joint MAFMC and NEFSC dogfish management plan for federal waters and/or the ASMFC plan for state waters. Three scenarios utilize an F-based strategy with constant fishing mortality rates over a 30 year projection period. The other three scenarios utilize a fixed quota over a 30 period.

The status quo F scenario assumes that the fishing mortality rate estimate in 2002 would continue through from 2003 to 2032. No assumptions about the relative allocation of yield between the US and Canada are made but the current rate of F is based on the summation of landings from both countries. The rebuilding level of F is based on projection results from an earlier version of the model. Given the initial conditions of the resource in 1997 and the model formulation, a fixed level of F= 0.03 was determined to be adequate to rebuild the stock within the 10-year rebuilding period specified by the Sustainable Fisheries Act (SFA). Finally, an implausible scenario of zero fishing mortality was employed to evaluate the minimum possible rebuilding time. The utility of this scenario is that it provides a benchmark to compare alternative scenarios.

Three quota-based scenarios were also evaluated. In each of these scenarios it was assumed that the future level of landings in Canada would remain near its current value of about 3,400 mt. It was further assumed that landings from the US would be additive. The base quota scenario assumes that US commercial fisheries extract a target quota of 4 M lb (1,814 mt) and Canadian landings remain at 3,400 mt. The “alternative” quota evaluates the effects of an 8.8 M lb (3,992 mt) US commercial landings and 3,400 mt in Canada. Finally, the “No Commercial Quota” scenario assumes that no dogfish would be landed in US fisheries.

The scenarios are designed to evaluate the relative merits of possible alternatives, rather than to accentuate allocation issues. The “status quo F”, “base quota”, “alternative quota” and “No US Commercial Quota” scenarios provide feedback on what might be accomplished under US regulatory measures. The “zero F” and “rebuild F” scenarios would require joint management by the US and Canada.

For all scenarios, it was assumed that the current rate of discard mortality would prevail for the projection period. Moreover, recreational fishery was assumed to consist mainly of discard mortality with no targeted effect of discarding.

The relative merits of each alternative scenario can be evaluated with respect to the magnitude of landings and the attainment of biological reference points. For each year in a scenario, 500 realizations of F and biomass are computed. Each of these is compared to threshold and target F and biomass levels. In addition, each simulated value of F was compared to an $F_{rebuild}$ level = 0.03 per the various management plans. The number of times that the F reference points were exceeded divided by the number of bootstrap intervals (500) represents a measure of the probability of exceeding the reference value. Similarly, the count of Biomass levels above the target level represents probability of restoring the population. Count of biomass above the threshold level could be interpreted as the shift in status from the “overfished” condition.

The projection model output was condensed to provide rapid comparison among alternatives. First, box plots were used to summarize the projected range of model outputs for key management variables {1)Yield (mt total, female, male), 2) Discards (mt), 3) SSB (mt), 4) F, 5) Fraction of the SSB target and 6) Total biomass (mt)}. To further reduce the information, these quantities were tabulated as averages on a decadal time scale (Table 9.1) and as a series of 10 year waypoints (Table 9.2). It should be noted that the current non-equilibrium status of the population induces transient oscillations in abundance. These oscillations should be kept in mind when evaluating the tabulated waypoint data. In particular, it is expected that some scenarios will rapidly attain restoration followed by a decline in abundance at the effects of recent low levels of recruitment feed into the adult stock. The input files and probability output files are included in Appendix 4. The following sections provide additional details on the results of the simulation model.

9.4.1 Status quo F

Under the status quo F scenario, the population exhibits wide variation in SSB and yield. (Figure 9.1). Both of these oscillations are induced by the non equilibrium size structure of the population. The population does not achieve rebuilt status but does stabilize at about 100 k mt of SSB supporting about 8,000 mt of yield. The stabilization occurs because the joint effect of the current fishing mortality rate and discard rate closely approximate the predicted equilibrium threshold F of about 0.11. As a result, population stability is achieved by about 2020.

9.4.2 Rebuild F

The rebuild F option is based on recommended fishing mortality rates specified in the federal FMP. The target rate of F=0.03 is based on an earlier version of the model presented herein. Under this option, the population rebuilds rapidly but then oscillates as the effects of the paucity of 36-79 cm initial population is felt about 10 years into the simulation (Figure 9.2). The effects occur in both the yield and SSB trajectories. Population rebuilding occurs in 2020. The model uses a constant F but presumably a more liberal fishing mortality rate could be applied at that time.

9.4.3 Zero F

The zero F option is designed to benchmark the minimum possible rebuilding time. Under this assumed option the population is predicted to have a 50% of exceeding the target biomass level in 2017 (Figure 9.3)

9.4.4 Base Quota

The baseline quota option represents continuation of the current level of total landings in the US and Canada. The current quota level results in a gradual increase in population size allowing rebuilding by about 2026 (Figure 9.4).

9.4.5 Alternative Quota

The alternative quota option (Figure 9.5) fails to achieve rebuilding over the 30-yr period of the simulation.

9.4.6 No Commercial Quota

This option results in a rebuilding of the population by 2020 (Figure 9.6). The model results suggest that a quota of about 3,400 mt, however allocated, could be harvested without severely delaying the rebuilding time that would occur under the zero F option.

9.4.7 F=0.08 in 2004 and later

This scenario corresponds to the target fishing mortality rate specified in the federal FMP. Yield under this scenario fluctuates around 9,000 mt, but the population never rebuilds over the 30 year horizon.

9.4.8. Status Quo F and Maternal Effect on first year Survival

Projection model simulation results under the assumption that the status quo F continues and first year pup survival is expressed as a function of maternal size (Figure 8.2) are provided in Figure 9.8. This scenario suggests that the population will neither rebuild nor stabilize under the status quo F.

9.4.9 Summary

No density dependent factors associated with high densities are included. This is appropriate for dogfish in view of the low present state of the female spawner biomass and limited range for compensation in terms of growth and pup production. The absence of density-dependent regulation is justified also by the steepness of the SR function at the origin. This projection model is considered adequate for describing the dynamics of the resource up to the point of restoration, i.e., attainment of the biological reference point for biomass.

Important caveats apply to ALL of the above simulations. No assumptions are made about possible size dependent decreases in pup viability. It is assumed that pup survival is constant for pups produced by all females, regardless of maternal size. If the size-dependent decreases in initial survival rates are real, then all of the scenarios would be considered optimistic with respect to rebuilding the populations. Further, it is assumed that the current discard pattern persists into the future. Another important factor is that the minimum footprint is assumed to apply. While the exact expansion factor (A/a) is unknown, the true value is likely to be between the min and max footprint assumptions. If so, appropriate caution should be applied when considering long-term quota options. Earlier projections of stock biomass under the max footprint assumption suggested that the range of quota levels that gave increasing versus decreasing populations was fairly narrow.

10.0 Simple Mass Balance Models

The SARC expressed concerns regarding the utility of the nominal footprint (0.01 nm^2) analyses of survey data as an adequate measure of true stock abundance. The SARC suggested that model- based approaches would be an alternative means of estimating the likely magnitude of q and therefore, efficiency, defined as the probability of capture given encounter. To test this concept two alternative mass balance models were applied. The following analyses were conducted during the SARC and are intended to provide an initial exploration of the utility of model-based methods of estimating abundance. A simple Leslie-Davis model, based on a closed population was applied, primarily as a means of circumscribing the possible value of q. The second model was based on a simplified catch survey analysis, similar to the process model of Collie and Sissenwine.

As in all analyses of survey data for spiny dogfish, data are averaged across years to provide a better estimate of abundance. This tends to dampen interannual changes.

If we consider the reduction of female dogfish abundance since 1989 as a simple depletion experiment wherein the slow growth of dogfish above 80 cm, and low mortality combine to result in low recruitment and biomass production, a Leslie-Davis model is a plausible approach. Under this assumption the change in abundance could be viewed as a simple depletion experiment. If the index data are scaled to the nominal footprint, the slope of the Leslie Davis regression is a measure of the efficiency of the trawl. Results of the Leslie Davis application are provided in Figure 10.1. The slope estimate of 1.23 is consistent with an effective footprint approximately equal to the increased contact time of the trawl. As a very rough approximation, the efficiency of the trawl for dogfish should be on the order of 0.0123/0.0239~50%. (Note: the value of 0.0239 nm^2 corresponds to a trawl footprint defined as the distance between the trawl doors. This indirect measure of trawl efficiency further assumes that dogfish herd in between the doors.)

The Leslie Davis model makes strong, and perhaps untenable, assumptions about constancy of recruitment and offsetting effects of growth and natural mortality. To address these concerns a more complicated mass balance model was devised. The model is similar to that proposed by Collie and Sissenwine, except in this instance, it was assumed that all of the error is process error, rather than observation error. Thus, the model boils down to one parameter as follows.

Define recruits R_t as the biomass of dogfish in the 79 cm range that will grow into the 80 cm range in the next time step. The biomass of 80+ cm dogfish will change between time steps in response to the growth of individuals (G), losses through natural mortality (M), and biomass removals by the fishery C_t. Basing the expanded values of B and R on a nominal footprint of 0.01, the model can thus be defined as

$$B_{t+1} = B_t e^{G-M} + R_t - C_t$$

The G and M parameters are not separably estimable but their difference can be estimated as a single parameter, say ϕ. The model estimate of ϕ was -0.061 which corresponds well with the assumed natural mortality rate of 0.092 and a very slow adult growth rate. Results of the model fit are summarized in Figure 10.2. The model fits well with no aberrant residual patterns. The model now adequately tracks the recent change in abundance, a small upturn in the last 3 yrs. This appears to be due to a decrease landings, since the difference between the recruitment and the landings becomes positive in 2001 and 2002. (Figure 10.2 bottom panel.).

Both the Leslie-Davis and simple mass-balance models support the concept that the nominal footprint assumption adequately characterizes the true size of the population. The rapid change in the size structure, and paucity of pups in recent years also provide evidence that the removals in the directed fishery were sufficient to exert a relative large mortality on the adult stock.

11.0 Spiny Dogfish Research Recommendations

New

1) Attempt to allocate landings to statistical area (i.e. attempt proration) using Vessel Trip Report data for 1994 and later years.

2) Evaluate the utility of length frequency for spiny dogfish sampled in the NEFSC Observer Program in the most recent years (2001 and later).

3) Ensure the inclusion of recent (2000 and later) MADMF Observer sample data for spiny dogfish in the NEFSC database, for more efficient use in future assessments.

4) Conduct tagging and genetic studies of spiny dogfish in U.S. and Canadian waters to clarify current assumptions about stock structure.

5) Conduct discard mortality studies for spiny dogfish, with consideration of the differences in mortality rates among seasons, areas, and gear types.

6) Conduct experimental work on NEFSC trawl survey gear performance, with focus on video work to study the fish herding properties of the gear for species like dogfish and other demersal roundfish.

7) Investigate the distribution of spiny dogfish beyond the depth range of current NEFSC trawl surveys, possibly using experimental research or supplemental surveys.

8) Initiate ageing studies for spiny dogfish age structures (e.g., fin spines) obtained from NEFSC trawl surveys and other sampling programs. These studies should include additional age validation and age structure exchanges. The WG notes that other aging methodologies (e.g., Canadian studies on radiometry) are also in development.

9) Explore an alternative assessment which uses a standard statistical fisheries modeling approach (i.e., data inputs not smoothed before fitting the model, and trawl biomass used as relative indices with a selectivity pattern estimated within the model).

Old: Pending

1) Additional analyses of the effects of environmental conditions on survey catch rates should be conducted.

Old: In Progress

1) Additional work on the stock-recruitment relationship should also be conducted with an eye toward estimation of the intrinsic rate of population increase.

2) The SARC noted that the increased biological sampling of dogfish should be conducted. Maturation and fecundity estimates by length class will be particularly important to update. Additional work on the survey database should be conducted to recover and encode information on the sex composition prior to 1980.

Old: Completed

1) The SARC recommended continued work on the change-in-ratio estimators for mortality rates and suggested several options for analyses.

The change-in-ratio estimator approach was not successful, and has been dropped from the assessment.

2) The SARC noted the absence of projections for this species and recommended the development of a projection model.

Projections are now included in the assessment.

3) The SARC recommended additional analyses of sea sampling data since 1994. Further analyses of the commercial fishery is also warranted, especially with respect to the effects of gear types, mesh sizes, and market acceptability on the mean size of landed dogfish.

Discard estimates based on sea sampling (observer) data are now included in the assessment.

4) The SARC noted the potential importance of dogfish predation in the ecosystem and recommended further work on the diet composition.

See Link et al, 2002 (N. Am. J. Fish. Mgmt. 22:550-562).

12.0 SARC Comments

12.1. Discussion on Life History, Discard Estimation and Survey Trends

The Stock Assessment Review Committee (SARC) discussed the different longevity estimates for the east and west cost. The east coast assumes spiny dogfish live for fifty years, whereas on the west coast it is assumed that dogfish live for 100 years. There is some evidence that the west coast ageing consistently doubles the ages assigned to the rings on the second dorsal spine resulting in a life span twice as long as the east coast. There does not appear to be any evolutionary reason for the Pacific spiny dogfish to live twice as long as the Atlantic spiny dogfish. While there is a need for more ageing work, the SARC determined that a life span of fifty years is the based best available information at this time.

The stock assessment assumes 100% of the spiny dogfish discarded in the recreational fishery are discarded dead. Estimates of discard mortality in the recreational fishery are based on the treatment of dogfish on charter boats. The SARC discussed the appropriateness of the assumed discard mortality rates in the assessment because the commercial hook and line fishery has an assumed discard mortality rate of 25%. Information on discard mortality rates in the spiny dogfish recreational and commercial fisheries is lacking.

Due to recent management decisions to employ a different quota determination methodology to estimate the annual commercial quota, some members of the Committee felt that the SAW/SARC process would have been an appropriate venue to review the new quota determination model. While fishery managers are responsible for selecting the fishery's quota, the SARC could have provided some advice on the potential implications on the stock. The SARC felt it should conduct a technical review of the models used to estimate annual quotas.

Observed patterns from the NEFSC trawl survey show that the number of pups in a litter has changed over time, from 5–15 to 2-10. Litters over ten pups are a rare occurrence. There is some variability in the number of pups in a litter, but, generally, the number of pups in a litter increases with the length of the female.

Biological sampling of spiny dogfish has been sporadic because the species does not have a high priority. Massachusetts Division of Marine Fisheries does perform some port and sea sampling for spiny dogfish, although the timing of commercial landings has challenged the ability to obtain biological samples. Commercial landings come in over a short period of time because of the current management scheme and the low quota.

The Committee discussed the use of inshore surveys, such as the Maine and New Jersey surveys. These surveys would complement the current catch rate information from the NEFSC trawl survey, but would not supplement the information collected on the biological attributes of the resource (e.g. length and sex), which are critical to the stock assessment.

It was suggested that the discard estimates should have confidence intervals, derived from a more robust method such as bootstrapping.

Catch per unit effort should be incorporated into the discard estimation, but defining a standardized unit of effort between the different gear types would be difficult. Much of the data are for short trips, so the definition of a trip for a small gillnet vessel will be different to that of bigger trawl vessels. Future work on estimating discards could include GLM or other models using catch per unit effort, vessel classification and other covariates.

The assessment uses information collected from the NOAA Fisheries Observer Program to determine an estimation of the level of discards associated with different gear types. The catch-based discard estimation focused on three different gear type predominantly used when targeting spiny dogfish; gillnets, hook and line, and trawls. The estimation included only trips where spiny dogfish was not the primary target species, and therefore assumed to be bycatch.

At a previous SARC, the winter, fall, and spring surveys were reviewed to determine the most appropriate survey to characterize the stock. During the time of year that the spring survey is conducted, about 90% of the spiny dogfish population inhabits the same area covered by the survey. This earlier SARC review also revealed that when the abundance dropped in the fall survey, the absent portion of the resource appeared in the Canadian survey. This implies that the US fall survey and the Canadian survey combined may track abundance of the entire population, but NEFSC spring survey alone provided the best representative sample of the entire population.

The assessment did not review the NEFSC trawl survey to determine if there was a spatial trend associated with the characteristics of mean size of females and pups.

The Committee discussed the influence of environmental variation creating a size dependent response. The length frequencies in the survey reveal that the mature females over 80 cm have not been captured by the survey over the last six or seven years. The same evidence is seen in the commercial landings. At one point, it was common for the fishery to harvest females over 100 cm. The males are commonly found along the continental shelf, whereas the females tend to be found inshore. The spatial movements of the sexes might be a reason for the biological characteristics seen in the survey.

Future work on the assessment should include a review of the environmental variables associated with the encounter of spiny dogfish during the NEFSC trawl spring, like temperature and depth. The survey area should be stratified by temperature to determine if the temperature drives the dogfish to a different geographical location each year. Also, if the survey is partition into three or four strata, the data may reveal whether the biological characteristics are different in each area.

It was noted that the assessment may overestimate the spawning stock biomass if the pup viability is not taken into account in management decisions.

12.2. East Carolina University Spiny Dogfish Tagging Data

The North Carolina spiny dogfish fishery typically encounters more females than males. The fishery also takes place during the winter when the dogfish have migrated south. The weather during the winter prohibits fishermen from fishing out on the continental shelf. Data from the NEFSC trawl survey shows that the males tend to be in the deep waters off North Carolina at about 200 m.

The majority of the tag returns were in the US; only one or two were captured in Canadian waters. A possible explanation for the low return rate in Canada is the difference in effort. For the time period covered by the study, the US effort was about four to five times the Canadian landings. To determine the migrational patterns in the northern range of the species, tagging studies need to be conducted off Cape Cod, Massachusetts.

The tagging study should consider the associated handling mortality. It is assumed to be low because the dogfish are released soon after they are captured. The condition of the spiny dogfish should be assessed and recorded prior to releasing the fish. There was some concern that recapture of fish released from gillnets was much lower than those released from trawl, which may be due to tag induced mortality.

The tagging study is encountering a considerable number of dogfish that may not be caught by the fishery. The study should determine if there is a difference in size between the fish caught by the different gear types (e.g. trawls versus gillnets).

The population estimate derived from the tagging study is three times the estimate derived from the swept area estimate. The tagging study should factor in the possibility that dogfish are double tagged and tag shedding rates.

The tagging study used two different reward levels. Every tenth tag released was a $50 reward; all of the remaining tags offer a $10 reward. The different reward levels did not influence the reporting rate.

The biomass estimates derived from the gillnet study should factor in the probability of being captured associated with the distance from the gillnet.

The tagging work in North Carolina should be combined with the gillnet study to provide a better population estimate.

12.3. Discussion on Biological Reference Points and Projections

The Committee discussed the catchability associated with the trawl survey. The catchability may be influenced by a significant amount of herding in front of the doors.

The current target biomass uses the female spawning stock biomass. The target biomass was selected based on the number of pups that will survive to replace the mature female in the population so that the population remains stable. The Committee suggested using fecundity as an alternative target to spawning stock biomass. The spawning stock biomass may not be the best target due to the uncertainty associated with the survey area-swept method. The assessment derived a predicted number of pups in the population based on the abundance and length frequencies of the mature females. The predicted number of pups in the population was overestimated compared to the observed number of pups in the survey.

Stochastic Biomass Estimates

The stock assessment introduces a new method for estimating biomass to replace the Beverton - Holt method used in previous assessments. The stochastic biomass estimator requires a set of assumptions. The biomass encountered by the NEFSC trawl survey is representative of the entire population and the availability of the resource is assumed to be equal over the entire survey area. The survey biomass also represents the size composition of the population, so all lengths are equally selected by the trawl survey. The length composition of the survey biomass is averaged over 3 years to reduce the survey variability.

It was questioned whether using swept area without taking into account vulnerability (i.e. assuming vulnerability = 1) could be used to obtain realistic biomass estimates. The three components of catchability are vertical availability, area availability and vulnerability to the survey gear. Vertical availability was assumed to be high as dogfish tend not to move far from the sea floor and area availability is already considered in the assessment. The biomass estimates derived in the survey produces a lower and upper bound on the biomass based on the area availability. The spring survey is assumed to encounter about 90% or more of the population.

A range of biomass estimates are produced in the assessment because of the uncertainty associated with the area swept by the survey. The minimum footprint of the survey is based on the area swept between the wings of the net. The minimum footprint translates into the maximum biomass estimate. The maximum footprint uses the area between the doors of the net and is the basis for the minimum biomass estimate. The doors may be creating a herding effect making the effective footprint the area swept between the doors. The Committee suggested the use of underwater video equipment on the net to determine if herding does occur, and, more generally, vulnerability to the gear.

The NEFSC spring survey is assumed to be the best indicator of the overall stock structure. Commercial landings are used to determine the size frequency and commercial selectivity. The assumption is that the commercial gear is fishing in a smaller size range than the entire population. The selectivity in the fishery exists because of market demand for a certain size range of dogfish.

The stochastic biomass estimator shows an increase in exploitable biomass in 1995 and 1996, which coincides with the increase in commercial landings. At this time, a large portion of the landings was male, so the force of mortality was over a greater portion of the entire population, influencing the selectivity for the fishery.

The biomass estimates are being used as absolute abundance estimates, when the estimates are probably relative abundance. It was pointed out that trawl surveys are not usually used to estimate absolute biomass. However, absolute biomass estimates are needed to derive the annual quota and no alternative is currently available. It was suggested that the assessment moved towards a fully age or size structured model and use the trawl survey as an index of relative abundance.

Additional research on ageing spiny dogfish is needed to resolve the ageing discrepancy between the east and west coast. Age information will reduce some of the uncertainties introduced by converting length frequencies to age classes.

It appears that spiny dogfish is an possible candidate for a biomass dynamics model, but the estimates derived in 1994 were poor and the model was not pursued further.

In recent years, the stochastic biomass estimator shows a convergence of the exploitable and spawning stock biomass. Variation in growth rates between individuals in the population should and can be introduced into the model. The current assessment assumes that there is no variation in growth rates. The model also assumes that the population is at equilibrium, although, it is clear that the population has not reached equilibrium.

Projections

The projection model should be configured so that the recruits to the population are a function of the population size. This will more accurately model the current condition of recruitment and implication of improved recruitment as the population.

The number of pups in a litter is proportional to the length of the female. An estimate of predicted pups can be derived based on the length frequencies of the females in the population. The pup survival rate is dependent on the average size of pups. The pups produced by smaller females are generally smaller in size, and therefore have a lower survival rate than the pups produced by larger females. Evidence of recruitment failure over the past seven years appears in the declining abundance of the immature dogfish between 50 cm and 60 cm.

The stochastic biomass estimator relies on the catchability of the survey to derive estimates of biomass and fishing mortality. In the interim, a connection should be made between the target female spawning stock biomass and an index of fecundity that could be used in future management decisions. The Committee suggested using pup production per tow or the number of mature females per tow multiplied by the number of pups that can be produce at sizes encountered in the tow.

Uncertainty in the F target has not been explicitly considered. Uncertainty in the target biomass could be characterized using bootstraps or other methods. It was suggested a full risk analysis could be conducted.

The Committee has more confidence in the relative abundance estimates. The relative abundance estimates should be used in the fishery management plans, but it would acceptable to use both the upper and lower bounds of the absolute biomass estimates. The footprint of the trawl survey creates a lot of uncertainty in the absolute abundance estimates. Further exploration into the use of a fecundity index needs to be conducted and would be recommended index for a biomass rebuilding target.

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Table B4.1. Total spiny dogfish landings (mt, live).

					US Recreational		
Year	Canada	US	USSR	Other Foreign	Landed	Discards	Total
1962	0	235	0	0		NA	235
1963	0	610	0	1		NA	611
1964	0	730	0	16		NA	746
1965	9	488	188	10		NA	695
1966	39	578	9389	0		NA	10006
1967	0	278	2436	0		NA	2714
1968	0	158	4404	0		NA	4562
1969	0	113	8827	363		NA	9303
1970	19	106	4924	716		NA	5765
1971	4	73	10802	764		NA	11643
1972	3	69	23302	689		NA	24063
1973	20	89	14219	4574		NA	18902
1974	36	127	20444	4069		NA	24676
1975	1	147	22331	192		NA	22671
1976	3	550	16681	107		NA	17341
1977	1	931	6942	257		NA	8131
1978	84	828	577	45		NA	1534
1979	1331	4753	105	82		NA	6271
1980	670	4085	351	248		NA	5354
1981	564	6865	516	458	1493	296	10192
1982	953	5411	27	337	70	349	7147
1983		4897	359	105	67	540	5968
1984	4	4450	291	100	91	424	5361
1985	13	4028	694	318	89	964	6107
1986	21	2748	214	154	182	1187	4506
1987	280	2703	116	23	306	1056	4484
1988		3105	574	73	359	876	4987
1989	166	4492	169	87	418	1344	6676
1990	1316	14731	383	10	179	1170	17788
1991	292	13177	218	16	131	1350	15183
1992	829	16858	26	41	215	1019	18987
1993	1411	20643	0	27	120	1110	23311
1994	1819	18800	0	2	154	969	21744
1995	948	22711	0	14	64	628	24365
1996	416	27241	0	236	34	353	28279
1997	446	18352		214	64	749	19825
1998	1079	20628		607	39	610	22962
1999	2467	14860		554	53	532	18466
2000	2677	9257		494	5	604	13036
2001	3755	2294		302	28	2090	8468
2002	3400	2195			225	1698	7518

A. The increase in foreign landings from 1996 on may be other species of squalid sharks.

13016.53
28279.14
1534.45

Table B4.2. Spiny dogfish landings (mt, live) by gear type.

Year	Gear Type					
	Line Trawl	Otter Trawl	Sink Gill Net	Drift Gill Net	Other Gear	Total
1962	18.7	78.3	0.0	129.4	8.4	234.9
1963	49.8	85.5	297.2	138.3	38.8	609.6
1964	12.5	75.4	89.5	529.5	23.4	730.4
1965	55.1	52.3	129.8	228.6	22.2	488.0
1966	84.7	95.2	173.2	184.8	40.1	578.1
1967	23.9	110.8	54.9	43.1	44.9	277.5
1968	2.5	78.0	0.0	54.3	23.2	158.0
1969	1.9	88.4	0.5	5.9	16.7	113.4
1970	1.8	80.5	9.6	2.8	11.0	105.7
1971	0.0	53.0	0.6	3.5	16.2	73.3
1972	0.6	53.5	0.6	0.1	14.4	69.2
1973	0.5	76.7	1.3	5.0	5.8	89.4
1974	1.9	79.2	1.1	10.2	34.9	127.3
1975	0.3	89.4	4.1	10.3	42.8	146.9
1976	5.2	71.6	432.9	5.4	34.5	549.6
1977	2.8	102.6	796.1	2.8	27.2	931.4
1978	3.4	121.4	680.8	6.3	16.6	828.4
1979	17.8	3518.0	1251.8	1.5	17.6	4806.5
1980	21.3	3370.1	635.3	4.0	64.7	4095.4
1981	1.0	6287.1	628.2	7.3	8.7	6932.4
1982	2.9	5065.6	310.7	9.4	22.0	5410.6
1983	0.2	3367.5	1517.1	6.6	5.1	4896.5
1984	0.9	2486.0	1949.5	6.1	7.9	4450.4
1985	158.7	2844.4	1007.6	9.8	7.6	4028.0
1986	2.6	1258.1	1467.2	3.1	16.7	2747.6
1987	7.8	1848.1	811.7	2.9	32.8	2703.4
1988	4.7	1589.5	1489.5	12.6	9.0	3105.2
1989	138.2	486.5	3839.0	7.5	20.8	4492.0
1990	16.8	7010.8	7685.2	14.7	3.1	14730.6
1991	31.1	5208.7	7805.8	107.6	23.6	13176.7
1992	9.8	4785.5	11639.7	171.5	251.4	16857.9
1993	250.8	5100.2	15764.9	77.3	22.7	21215.9
1994	482.4	3056.3	14798.2	27.1	134.1	18498.2
1995	1494.3	2818.0	17657.4	340.9	272.1	22582.6
1996	1313.0	3408.2	21088.7	1265.3	99.0	27174.1
1997	1084.6	1800.6	14357.1	1026.4	84.1	18352.9
1998	1410.0	2709.2	15071.4	1315.4	121.6	20627.6
1999	1610.8	2212.5	10462.8	325.4	248.5	14860.0
2000	1776.1	3146.8	4297.6	15.9	20.3	9256.7
2001	1276.3	254.4	749.0	0.7	13.1	2293.6
2002	1044.1	247.7	896.0	0.5	6.5	2194.8

Table B4.3. Spiny dogfish landings (mt, live) by month,1964-2002.

		Month												
Year	Unk	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1964	627.9	7.3	1.4	1.2	-	12.9	31.7	-	4.8	35.9	-	-	7.4	730.3
1965	308.5	0.1	4.1	-	14.9	4.9	34.4	23.1	27.2	30.8	11.9	22.6	5.6	488.1
1966	318.4	1.5	1.8	7.8	7.1	2.1	68.7	82.0	48.9	26.6	5.5	7.6	-	578.1
1967	188.3	-	3.9	-	4.3	6.0	15.9	42.7	5.3	7.2	0.9	2.5	0.8	277.5
1968	157.6	-	-	-	-	0.1	-	-	0.2	-	-	-	-	158.0
1969	113.4	-	-	-	-	-	-	-	-	-	-	-	-	113.4
1970	102.8	-	-	-	-	-	-	0.3	1.0	0.2	0.9	0.4	<0.1	105.6
1971	72.9	<0.1	-	-	-	0.4	-	-	-	-	-	-	-	73.3
1972	60.2	-	-	-	0.1	0.4	0.3	-	-	-	1.8	4.7	1.7	69.2
1973	73.7	2.7	<0.1	-	0.7	2.4	4.3	2.4	0.3	-	1.6	0.8	0.4	89.3
1974	122.6	0.1	-	0.9	-	0.8	0.3	1.1	0.2	0.6	0.4	0.2	0.1	127.3
1975	136.0	0.2	0.1	0.4	2.6	0.3	0.2	0.2	0.1	-	0.1	3.6	2.9	146.9
1976	116.2	0.1	0.5	-	-	-	24.1	126.2	70.9	119.7	91.8	0.1	0.1	549.7
1977	95.4	0.0	-	-	-	30.0	259.9	120.4	169.4	136.7	98.3	4.1	17.3	931.4
1978	140.8	0.1	0.8	5.9	0.1	0.5	85.0	294.5	102.2	54.2	133.0	9.1	2.3	828.5
1979	344.3	-	-	-	-	16.7	292.4	637.0	502.3	1043.1	1137.5	389.8	389.5	4752.7
1980	406.7	26.9	3.3	81.5	0.4	112.3	803.0	540.5	818.9	1087.4	52.2	91.4	60.7	4085.1
1981	1729.4	1.2	0.4	-	0.8	107.6	945.4	1121.0	1156.8	1005.2	698.6	98.0	0.7	6865.0
1982	65.8	143.1	369.6	1287.8	219.4	134.1	830.4	819.7	411.6	517.6	256.4	235.7	119.4	5410.6
1983	45.9	3.7	3.6	-	0.3	55.8	140.8	710.0	963.2	744.5	402.5	169.2	1656.9	4896.5
1984	46.8	-	-	-	0.3	1.4	559.5	2077.1	1111.6	357.8	168.2	103.1	24.5	4450.4
1985	71.1	-	-	0.8	1.9	275.5	690.6	753.2	785.6	588.1	642.6	175.4	43.0	4027.9
1986	13.1	1.0	5.8	2.5	11.8	145.5	483.1	468.0	473.7	622.8	376.9	93.8	49.9	2747.6
1987	6.0	4.8	1.5	4.0	8.6	17.6	397.1	555.8	384.6	440.5	703.6	175.5	3.9	2703.4
1988	49.8	0.6	116.0	27.5	4.4	384.8	566.3	532.4	502.6	508.8	401.1	9.9	0.9	3105.1
1989	15.5	0.2	-	2.0	21.2	296.9	1134.1	713.5	961.4	924.5	374.2	41.7	6.8	4492.0
1990	49.5	290.0	207.8	283.2	318.6	494.2	1137.9	2881.6	2819.3	2079.5	1166.8	959.8	2042.6	14730.6
1991	213.7	1609.9	1105.2	661.4	1298.9	1136.8	624.5	1421.6	962.8	840.1	353.7	965.7	1982.6	13176.6
1992	320.8	2117.3	1620.4	1402.6	703.7	787.5	1083.4	2327.4	1549.7	808.9	1362.7	1887.9	885.8	16857.9
1993	281.7	1516.3	1631.6	834.9	260.7	517.8	2001.0	3423.3	3227.4	2587.2	1983.3	1075.8	1301.8	20642.9
1994	77.1	1277.0	1438.2	1234.9	628.9	653.1	1975.3	3391.2	4204.7	1508.1	878.2	409.5	1123.9	18800.2
1995	28.7	1703.4	1432.8	1150.9	880.3	928.8	3386.9	4181.5	2208.8	1843.9	1887.2	1499.9	1577.6	22710.6
1996	0.2	2628.1	2336.8	2532.1	1695.1	534.5	2221.9	3630.6	2466.7	2143.6	2511.0	2056.9	2483.5	27241.0
1997	0.0	2304.0	1543.4	1468.0	724.0	1419.6	2122.0	2684.4	1917.8	1055.3	1129.3	1070.9	914.2	18352.9
1998	0.0	1652.6	1304.4	1113.9	571.6	572.2	1415.7	2272.8	2983.1	2620.1	2922.1	1965.8	1233.2	20627.6
1999	0.0	1732.1	1701.1	1478.7	869.4	850.5	1761.3	1209.4	995.7	1085.5	1372.3	829.1	974.9	14860.0
2000	0.0	1215.6	1885.1	1771.1	698.1	61.6	595.7	1326.1	1029.7	267.3	222.0	110.1	74.1	9256.7
2001	0.0	5.4	0.0	0.2	17.0	144.6	1048.2	2.2	3.3	1.5	1.0	1070.1	0.1	2293.6
2002	0.0	0.2	0.1	1.2	40.7	489.9	889.0	3.2	3.1	1.0	0.5	725.6	40.3	2194.8

Table B4.4. Landings of spiny dogfish (mt, live) by state (Includes 100% unclassified dogfish).

	State											
Year	Connecticut	Delaware	Maine	Maryland	Massachusetts	New Hampshire	New Jersey	New York	North Carolina	Rhode Island	Virginia	Total
1962	2.6	0.0	21.6	17.4	0.0	0.0	1.6	25.2	0.0	0.1	166.3	234.9
1963	0.1	0.0	343.5	16.5	0.0	0.0	1.9	35.4	0.0	0.1	212.2	609.6
1964	4.7	0.0	102.1	12.4	0.0	0.0	0.2	33.1	0.0	0.4	577.5	730.3
1965	6.9	0.0	171.3	7.2	7.6	0.0	0.7	43.9	0.0	0.7	249.7	488.1
1966	4.9	0.2	259.6	6.7	0.0	0.0	1.5	81.7	0.0	0.1	223.4	578.1
1967	1.6	0.0	82.1	6.5	6.6	0.0	0.1	89.0	0.0	0.5	91.1	277.5
1968	22.8	0.0	0.0	7.2	0.3	0.0	3.3	61.8	0.0	0.1	62.5	158.0
1969	2.2	0.0	0.0	7.9	0.0	0.0	6.1	65.6	0.0	0.1	31.6	113.4
1970	8.0	0.0	0.0	6.1	2.4	0.0	0.6	54.1	0.0	0.7	33.8	105.7
1971	4.1	0.0	0.0	1.5	0.4	0.0	5.6	50.5	0.0	0.1	11.1	73.3
1972	0.0	0.0	0.0	2.4	0.7	0.0	0.1	51.4	0.0	8.3	6.4	69.2
1973	0.1	0.0	0.0	4.5	5.4	0.0	2.5	44.4	0.0	10.4	22.2	89.3
1974	0.0	0.6	0.0	6.5	3.2	0.0	0.3	79.8	0.0	2.2	34.6	127.3
1975	0.0	1.8	0.0	2.6	1.8	0.0	0.9	101.1	0.0	9.1	29.5	146.9
1976	1.1	0.0	428.3	3.1	3.1	0.0	1.7	93.4	0.0	1.7	17.2	549.7
1977	1.0	0.1	792.8	3.6	17.4	0.0	4.7	78.1	0.0	26.4	7.4	931.4
1978	2.2	0.4	647.0	7.5	31.5	31.6	6.4	88.1	0.0	2.8	11.1	828.5
1979	4.1	0.1	1049.6	5.4	2964.9	140.6	392.4	96.7	0.0	1.6	97.6	4752.7
1980	0.1	0.1	619.1	5.0	2794.4	6.7	263.0	104.1	1.3	0.6	290.6	4085.1
1981	2.0	3.8	516.2	695.4	4523.3	0.0	92.5	50.1	2.0	1.7	978.1	6865.0
1982	1.2	1.2	282.6	895.2	2885.3	0.0	2.5	47.4	2.9	1.3	1291.0	5410.6
1983	4.3	2.0	225.0	96.5	4529.9	0.3	0.3	25.8	0.0	0.0	12.4	4896.5
1984	2.4	2.7	565.4	117.6	3703.2	0.1	4.1	35.0	0.0	11.1	8.8	4450.4
1985	4.5	0.0	409.8	76.9	3463.7	0.0	3.8	61.9	0.5	0.7	6.3	4028.0
1986	8.7	0.0	349.1	58.6	2165.6	0.0	24.0	133.9	0.0	2.2	5.5	2747.6
1987	2.9	0.0	271.0	3.5	2335.2	0.0	1.7	70.6	0.0	13.9	4.6	2703.4
1988	42.8	0.0	218.4	10.7	2643.6	0.2	4.6	39.2	136.9	0.3	8.6	3105.1
1989	0.4	0.0	2213.4	1.6	2233.8	0.0	10.3	21.9	0.0	2.0	8.7	4492.0
1990	11.0	0.0	2887.6	989.7	8077.0	84.0	2061.2	8.2	18.8	590.1	3.0	14730.6
1991	4.0	2.6	914.5	2240.4	6572.2	0.0	1231.8	35.0	663.7	1433.5	78.9	13176.6
1992	10.1	0.0	779.9	1389.5	8335.2	182.4	1149.7	70.6	3916.8	919.7	103.9	16857.9
1993	6.8	0.0	1598.9	814.6	12170.4	744.6	349.3	43.3	3994.4	872.9	47.7	20642.9
1994	77.1	0.0	822.5	648.0	10530.0	1178.4	512.5	107.7	4480.5	240.6	203.0	18800.2
1995	133.2	28.5	754.6	1414.1	13045.6	955.4	1083.4	423.9	4244.3	260.3	367.3	22710.6
1996	320.2	0.0	413.3	3243.7	12228.7	489.7	2102.6	602.2	6202.4	511.9	1126.3	27241.0
1997	157.6	0.0	203.5	1917.6	9827.0	746.9	1721.2	16.8	1365.5	629.7	1766.7	18352.4
1998	121.2	0.9	124.2	1088.2	11299.7	960.2	3416.7	3.0	1367.9	843.3	1402.2	20627.6
1999	39.9	0.2	15.8	968.0	6765.5	562.6	1812.3	678.3	1134.7	695.1	2187.8	14860.1
2000	13.7	0.1	3.5	204.0	2613.5	1058.9	2369.9	863.6	1319.9	154.4	655.2	9256.7
2001	3.4	0.0	0.1	0.1	1774.7	243.1	9.1	27.0	4.0	231.1	1.1	2293.6
2002	0.0	0.0	0.3	1.1	1723.1	158.2	0.6	23.6	0.7	284.9	2.2	2194.8

Table B4. Number of samples collected and number of individual spiny dogfish measured for length, by sex (U= unspecified; M-male; F=female), from USA commercial landings, by month, year and quarter, 1982-2002.

Year		Sex	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Q1	Q2	Q3	Q4	Total
1982	# of Samples		2	1	2									1	6	5	0	0	1	6
		U													0	0	0	0	0	0
		M	2		22										24	24	0	0	0	24
		F	198	101	281									100	680	580	0	0	100	680
1983	# of Samples							1		1	1	1	1		5	0	1	2	2	5
		U													0	0	0	0	0	0
		M													0	0	0	0	0	0
		F						104		118	121	133	134		610	0	104	239	267	610
1984	# of Samples							3	6	3	1				13	0	3	10	0	13
		U													0	0	0	0	0	0
		M						1	3	4	1				9	0	1	8	0	9
		F						286	745	351	117				1499	0	286	1213	0	1499
1985	# of Samples							2	1	3	3	2	2		13	0	2	7	4	13
		U													0	0	0	0	0	0
		M							1	1	14	1	4		21	0	0	16	5	21
		F						267	135	389	368	252	246		1657	0	267	892	498	1657
1986	# of Samples							3	1	4	3	2			13	0	3	8	2	13
		U						232							232	0	232	0	0	232
		M							45	1	10	8			64	0	0	56	8	64
		F						130	129	521	168	217			1165	0	130	818	217	1165
1987	# of Samples							3	6	2	1	2	1		15	0	3	9	3	15
		U													0	0	0	0	0	0
		M						16	4		1	1	9		31	0	16	5	10	31
		F						457	800	257	128	243	115		2000	0	457	1185	358	2000
1988	# of Samples						3	3	2	1	2	4			15	0	6	5	4	15
		U													0	0	0	0	0	0
		M							1	1		5			7	0	0	2	5	7
		F					371	364	238	128	230	433			1764	0	735	596	433	1764
1989	# of Samples							3	1	1	3	3			11	0	3	5	3	11
		U													0	0	0	0	0	0
		M								6	6	23			35	0	0	12	23	35
		F						352	127	137	390	369			1375	0	352	654	369	1375
1990	# of Samples							5	6	3	1	1	1	1	18	0	5	10	3	18
		U													0	0	0	0	0	0
		M							4			1	14		19	0	0	4	15	19
		F						593	775	358	135	111	123	135	2230	0	593	1268	369	2230
1991	# of Samples				1	1		2	4	2		1	1	2	14	1	3	6	4	14
		U							108			109			217	0	0	108	109	217
		M						11	127	12			8	3	161	0	11	139	11	161
		F			101	125		226	396	272			116	282	1518	101	351	668	398	1518
1992	# of Samples					1	2	4	6	4	1	2	4	1	25	0	7	11	7	25
		U						123							123	0	123	0	0	123
		M						2	1				8	1	12	0	2	1	9	12
		F				109	219	409	829	503	124	296	556	142	3187	0	737	1456	994	3187
1993	# of Samples						1	3	5	5	3	4			21	0	4	13	4	21
		U					133								133	0	133	0	0	133
		M								4	19	19			42	0	0	23	19	42
		F						400	683	776	369	545			2773	0	400	1828	545	2773
1994	# of Samples							3	6	4	2				15	0	3	12	0	15
		U							134						134	0	0	134	0	134
		M						2	31	14					47	0	2	45	0	47
		F						423	758	649	262				2092	0	423	1669	0	2092

Table B4.6. Summary of estimated landings of US and Canada commercial fisheries by sex. Port samples from NMFS and MADMF were pooled. Estimated total weights b summation of estimated weights from sampled length frequency distributions. Estimated weights computed from length-weight regressions. Females W =exp(-15.025)*L ^3.606935, Males W=exp(-13.002)*L^3.097787 with weight in kg, length in cm. "Samples"= number of measured dogfish.

	Composite (NMFS and MADMF) Biological Samples from Ports							Commercial Landings			Prorated Landings By Sex			
year	Total Samples Males	Est Tot Wt (kg) Males	Ave Wt (kg) Males	Total Samples (females)	EstTot Wt (kg) females	Est Avg Wt (kg) females	Fraction Females by weight	US Commercial Landings (mt)	Canada Landings (mt)	Tota Comm Landings (mt)	Est Landings (mt) of Males	Est. Landings (mt) of females	Number of Males Landed (000)	Number of Females Landed (000)
1988	7	14.8	2.114	1764	7561.4	4.287	0.9980	3105	0	3105	6.1	3098.9	2.9	722.9
1989	35	67.5	1.927	1375	5528.6	4.021	0.9879	4492	166	4658	56.1	4601.9	29.1	1144.5
1990	19	33.7	1.772	2230	8917.5	3.999	0.9962	14731	1316	16047	60.4	15986.6	34.1	3997.8
1991	23	37.8	1.643	1518	5924.5	3.903	0.9937	13177	292	13469	85.4	13383.6	52.0	3429.2
1992	12	22.3	1.861	3187	12181.9	3.822	0.9982	16858	829	17687	32.4	17654.6	17.4	4618.8
1993	42	78.4	1.866	2772	9923.1	3.580	0.9922	20643	1411	22054	172.8	21881.2	92.6	6112.5
1994	47	86.6	1.843	2091	6619.5	3.166	0.9871	18800	1819	20619	266.3	20352.7	144.5	6429.1
1995	25	38.9	1.555	2266	6677.3	2.947	0.9942	22711	948	23659	136.9	23522.1	88.1	7982.4
1996	569	886.7	1.558	1644	4398.0	2.675	0.8322	27241	416	27657	4640.3	23016.7	2977.8	8603.8
1997	303	449.1	1.482	382	780.9	2.044	0.6349	18352	446	18798	6863.4	11934.6	4630.5	5837.8
1998	68	85.4	1.257	683	1434.6	2.100	0.9438	20628	1079	21707	1220.2	20486.8	971.1	9753.4
1999	93	130.3	1.401	311	625.6	2.011	0.8276	14860	2467	17327	2986.8	14340.2	2131.9	7129.2
2000	405	561.2	1.386	5139	12157.9	2.366	0.9559	9257	2677	11934	526.5	11407.5	380.0	4821.8
2001	12	17.1	1.422	215	456.5	2.123	0.9640	2294	3755	6049	217.9	5831.1	153.3	2746.2
2002	65	97.6	1.501	1893	5065.8	2.676	0.9811	2195	3400	5595	105.7	5489.3	70.4	2051.2
formula	A	B	C=B/A	D	E	F=E/D	G=E/(E+B)	H	I	J=H+I	K=(1-G)*J	L=G*J	M=K/C	N=L/F

Table B4.7 Summary of species group assignments applied to landings records.

Lookup Table: Species_Code

Sp_Code	Group	Species Name
0	otherFish	UNKNOWN
1	otherFish	ALEWIFE
3	otherFish	AMBER_JACK
6	otherFish	BAY_ANCHOVY
12	monk	ANGLER
18	otherFish	BARRACUDA
19	otherFish	NEEDLEFISH_Atlantic
23	otherFish	BLUEFISH
24	otherFish	SQUIRRELFISH
25	otherFish	SQUIRRELFISH
27	otherFish	BARRELFISH
33	otherFish	BONITO
45	otherFish	BULLHEADS
51	squidbutterfish	BUTTERFISH
57	otherFish	COBIA
63	otherFish	CARP
66	otherFish	CATFISH
81	prin ground	COD
84	otherFish	CRAPPIE
87	otherFish	CREVALLE
90	otherFish	CROAKER_ATLANTIC
93	otherFish	CUNNER
96	otherFish	CUSK
98	otherFish	RIBBONFISH
104	otherFish	DRUM_NK
105	otherFish	DOLPHIN_FISH
106	otherFish	DRUM_BLACK
107	otherFish	DRUM_RED
112	pelagics	HERRING_BLUE_BACK
114	pelagics	HERRING_BLUE_BACK
115	otherFish	EEL_AMERICAN
116	otherFish	EEL_CONGER
117	otherFish	EEL_CONGER
120	flatfish	FLOUNDER_WINTER
121	fluke_4spot	FLOUNDER_SUMMER
122	flatfish	FLOUNDER_WITCH
123	flatfish	FLOUNDER_YELLOWTAIL
124	flatfish	FLOUNDER_AM_PLAICE
125	flatfish	FLOUNDER_SAND-DAB
126	flatfish	FLOUNDERS_(NK)
127	fluke_4spot	FLOUNDER_FOURSPOT
128	flatfish	HOGCHOCKER
130	flatfish	FLOUNDER_SOUTHERN
132	otherFish	MACKEREL_FRIGATE
133	otherFish	GARFISH
134	otherFish	GIZZARD_SHAD
138	otherFish	RN_GRENADIER
141	otherFish	GROUPER_SNOWY
142	otherFish	GROUPER_SNOWY
144	otherFish	GRUNTS
145	otherFish	GRUNTS
146	otherFish	GRUNTS
147	prin ground	HADDOCK
150	otherFish	HAGFISH
152	smallmeshground	HAKE_RED
153	prin ground	HAKE_WHITE
155	prin ground	HAKE_MIX_RED_&_WHITE
158	flatfish	HALIBUT_GREENLAND
159	flatfish	HALIBUT_ATLANTIC
165	otherFish	HARVEST_FISH
167	AtlHerring	HERRING_(NK)_
168	AtlHerring	HERRING_ATLANTIC_
171	otherFish	ARGENTINE__
173	otherFish	SHAD_HICKORY_
179	otherFish	HOGFISH__
188	otherFish	JOHN_DORY__

Sp_Code	Group	Species Name
268	otherFish	LADYFISH__
269	prin ground	POLLOCK__
272	otherFish	POMPANO_COMMON_
305	otherFish	SALMON_ATLANTIC_
309	otherFish	SALMON_UNCL_
311	otherFish	PERCH_SAND__
326	otherFish	SCULPINS__
327	otherFish	SEA_RAVEN__
329	scupSeaBass	SCUP__
330	otherFish	PORGY_RED__
331	otherFish	SCAD_ROUGH__
332	otherFish	SCAD_ROUGH__
333	otherFish	SCAD_ROUGH__
335	scupSeaBass	SEA_BASS_BLACK_
336	otherFish	SNAPPER__
340	otherFish	SNAPPER__
341	otherFish	SEA_ROBINS__
342	otherFish	SEA_ROBINS__
343	otherFish	SEA_ROBINS__
344	otherFish	WEAKFISH_SQUETEAGUE_
345	otherFish	WEAKFISH_SPOTTED_
346	OtherSharks	DOGFISH_CHAIN_
347	otherFish	SHAD_AMERICAN_
348	OtherSharks	SHARK_NURSE_
349	OtherSharks	SHARK_SAND_TIGER_
350	dogfish	DOGFISH_(NK)_
351	OtherSharks	DOGFISH_SMOOTH_
352	dogfish	DOGFISH_SPINY_
353	OtherSharks	SHARK_THRESHER_
354	OtherSharks	SHARK_THRESHR_BGEYE_
355	OtherSharks	SHARK_MAKO_SHORTFIN_
356	otherFish	SHEEPSHEAD__
357	OtherSharks	SHARK_MAKO__
358	OtherSharks	SHARK_MAKO_LONGFIN_
359	OtherSharks	SHARK_NK__
362	otherFish	SILVERSIDE_ATLANTIC_
365	skates	SKATES__
366	skates	SKATE_LITTLE_
367	skates	SKATE_BIG__
368	skates	SKATE_BARNDOOR_
369	skates	SKATE_BARNDOOR_
371	otherFish	SMELT__
374	otherFish	SNAPPER_VERMILLION_
375	otherFish	SNAPPER_DOG_
376	otherFish	SNAPPER_RED_
381	otherFish	SPADEFISH__
384	otherFish	MACKEREL_SPAN_
385	otherFish	ESCOLAR__
406	otherFish	SPOT__
415	otherFish	TROUT_STEELHEAD_
418	stripedbass	BASS_STRIPED_
420	sturgeon	STURGEON_ATLANTIC_
421	sturgeon	STURGEONS__
422	sturgeon	STURGEON_SHORT-NOSE_
423	otherFish	SUCKERS__
426	otherFish	SUNFISHES__
429	otherFish	PUFFER_NORTHERN_
432	LargePelagic	SWORDFISH__
435	otherFish	TARPON__
438	otherFish	TAUTOG__
444	otherFish	TILEFISH_BLUELINS_
445	otherFish	TILEFISH_SAND_
446	otherFish	TILEFISH_GOLDEN_
447	otherFish	TILEFISH__
451	otherFish	TOADFISH_OYSTER_
453	otherFish	TOM_COD__

Sp_Code	Group	Species Name
486	OtherSharks	SHARK_NIGHT_
487	OtherSharks	SHARK_BLACK_TIP_
488	OtherSharks	SHARK_SPINNER_
489	OtherSharks	SHARK_BULL__
490	OtherSharks	SHARK_WHITETIP_OC_
491	OtherSharks	SHARK_TIGER_
492	OtherSharks	SHARK_LEMON_
493	OtherSharks	SHARK_BLUE__
494	OtherSharks	SHARK_ATL_SHARPNOSE_
495	OtherSharks	SHARK_HAMMERHEAD_
496	OtherSharks	SHARK_BASKING_
497	OtherSharks	SHARK_LARGE_COASTAL_
498	OtherSharks	SHARKS_PELAGIC_
499	OtherSharks	SHARK_FINETOOTH_
501	OtherSharks	SHARK_SMALL_COASTAL_
502	OtherSharks	SHARK_RIDGEBACK_LG_
506	OtherFish	PERCH_WHITE_
507	smallmeshground	BLK_WHTNG&SLHAKE_MIX_
508	smallmeshground	WHITING_BLACK_
509	smallmeshground	HAKE_SILVER_
512	OtherFish	WOLFFISHES__
513	OtherFish	WRECKFISH__
517	OtherFish	PERCH_YELLOW_
524	OtherFish	OTHER GRNDFISH
525	mollusk	OTHER_PELAGICS_
526	mollusk	OTHER_FISH__
529	mollusk	OTHER_FISH__
700	crustacean	CRAB_BLUE__
701	crustacean	CRAB_LADY__
702	crustacean	CRAB_HERMIT_
708	crustacean	CRAB_GREEN__
710	crustacean	CRAB_RED__
711	crustacean	CRAB_JONAH__
712	crustacean	CRAB_ROCK__
713	crustacean	713_CRAB_NK__
714	crustacean	CRAB_CANCER_
716	crustacean	CRAB_CANCER_
718	crustacean	CRAB_QUEEN_SNOW_
724	crustacean	CRAB_HORSESHOE_
727	crustacean	LOBSTER__
733	crustacean	SHRIMP_ROYAL_RED_
735	crustacean	SHRIMP_(NK)__
736	crustacean	SHRIMP_(PANDALID)_
737	crustacean	SHRIMP_(MANTIS)_
738	crustacean	SHRIMP_(PENAEID)_
743	mollusk	743_CLAM_BLOODARC_
748	mollusk	QUAHOG__
754	mollusk	QUAHOG_OCEAN_
760	mollusk	CLAM_RAZOR__
763	mollusk	763_CLAM_SOFT__
764	mollusk	CLAM_NK__
765	mollusk	CLAM_SURF_ARTIC_
769	mollusk	CLAM_SURF__
775	mollusk	CONCHS__
776	mollusk	WHELK_CHANNELED_
777	mollusk	WHELK_KNOBBED_
778	mollusk	WHELK_LIGHTNING_
781	mollusk	MUSSELS__
786	mollusk	OCTOPUS__
789	mollusk	OYSTERS__
792	mollusk	OYSTER_EUROPEAN_FLT_
795	mollusk	SCALLOP_ICELANDIC_
796	mollusk	SCALLOPS_NK__
798	mollusk	PERIWINKLES__
799	mollusk	SCALLOP_BAY_
800	scallops	SCALLOP_SEA_

Table B4.8. Summary of gear codes group assignments.

Gear code	Gear Name
0	other
10	hook
20	other
21	hook
30	other
31	other
34	other
40	hook
41	other
50	trawl
51	trawl
52	trawl
55	trawl
56	trawl
58	shrimptrawl
59	trawl
60	other
61	other
62	other
64	other
65	other
66	other
70	other
71	other
80	other
90	other
91	other
100	gillnet
101	gillnet
102	gillnet
103	gillnet
105	gillnet
110	gillnet
112	gillnet
115	gillnet
116	gillnet
119	gillnet
120	other
121	other
122	other
123	other
124	other
131	dredge
132	dredge
140	other
141	other
142	other
143	other
160	other
170	other
180	other
181	other
182	other
183	other
184	other
185	other
186	other
190	other
200	other
201	other
202	other
203	other
204	other
205	other
206	other
210	other
211	other
212	other
220	other
221	other
222	other
223	other
230	other
231	other
240	other
250	other
251	other
252	other
253	other
254	other
260	other
270	other
281	other
282	other
290	other
300	other
301	other
310	other
320	other
322	other
323	other
330	other
331	other
332	other
340	other
350	other
351	other
360	other
370	other
380	other
381	dredge
382	dredge
383	dredge
384	other
385	other
386	other
387	other
400	dredge
410	other
411	other
412	other
413	other
414	other
420	other
430	other
500	other
510	other
520	other
525	other
530	other
563	other
999	other

Table B4.9. Master table of catch ratio based estimates of spiny dogfish discards by target species group and gear types for fishing years 1988-2002 Table updated 5/21/03

		gear	Data													
		gillnet			hook			trawl			Total Sum of Ntrips	Total Sum of Total Discards in mt	Total Sum of Var Total Discards (mt^2)		
Fishing Year	target sp	Sum of Ntrips	Sum of Total Discards in mt	Sum of Var Total Discards (mt^2)	Sum of Ntrips	Sum of Total Discards in mt	Sum of Var Total Discards (mt^2)	Sum of Ntrips	Sum of Total Discards in mt	Sum of Var Total Discards (mt^2)				SE (mt)	CV
1988	AtlHerring	0	0	0				0	0	0	0	0	0	0	
	crustacean	0	0	0				1	0	0	1	0	0	0	
	dogfish	0	0	0				0	0	0	0	0	0	0	
	flatfish	0	0	0	0	0	0	6	2910	1234508	6	2910	1234508	1111	0.382
	fluke 4spo	0	0	0				4	4076	4415033	4	4076	4415033	2101	0.515
	mackerel	0	0	0				1	55616	0	1	55616	0	0	0.000
	menhaden	0	0	0				0	0	0	0	0	0	0	
	monk	0	0	0	0	0	0	0	0	0	0	0	0	0	
	prin ground	0	0	0	0	0	0	9	289	35641	9	289	35641	189	0.654
	scupSeaBa	0	0	0				1	0	0	1	0	0	0	
	skates	0	0	0	0	0	0	0	0	0	0	0	0	0	
	smallmesh	0	0	0	0	0	0	6	3043	9848315	6	3043	9848315	3138	1.031
	squidbutter	0	0	0				6	564	73754	6	564	73754	272	0.481
1988 Total		0	0	0	0	0	0	34	66498	15607251	34	66498	15607251	3951	0.059
1989	AtlHerring	0	0	0	0	0	0	6	41	302	6	41	302	17	0.426
	crustacean	0	0	0				3	0	1	3	0	1	1	1.811
	dogfish	5	855	671303	0	0	0	6	234	659	11	1089	671962	820	0.753
	flatfish	20	0	0	0	0	0	47	17103	21574755	67	17103	21574755	4645	0.272
	fluke 4spo	0	0	0	0	0	0	5	56	977	5	56	977	31	0.560
	mackerel	2	2	0	0	0	0	2	2516	9305255	4	2518	9305255	3050	1.212
	menhaden	0	0	0				0	0	0	0	0	0	0	
	monk	4	1476	730852	0	0	0	5	6789	51652808	9	8265	52383660	7238	0.876
	prin ground	110	4394	1166154	0	0	0	33	4277	1761540	143	8671	2927694	1711	0.197
	scupSeaBa	0	0	0	0	0	0	4	3540	2224566	4	3540	2224566	1491	0.421
	skates	0	0	0	0	0	0	5	370	313141	5	370	313141	560	1.514
	smallmesh	0	0	0	0	0	0	41	4585	9146276	41	4585	9146276	3024	0.660
	squidbutter	0	0	0				25	4000	9246438	25	4000	9246438	3041	0.760
1989 Total		141	6727	2568309	0	0	0	182	43509	105226718	323	50236	107795027	10382	0.207
1990	AtlHerring	0	0	0				1	0	0	1	0	0	0	
	crustacean	0	0	0	0	0	0	4	2	5	4	2	5	2	1.230
	dogfish	10	1344	237682	0	0	0	3	8977	731969	13	10321	969651	985	0.095
	flatfish	22	10	85	0	0	0	30	10420	19482803	52	10430	19482888	4414	0.423
	fluke 4spo	0	0	0	0	0	0	6	3748	3755259	6	3748	3755259	1938	0.517
	mackerel	1	0	0	0	0	0	6	1204	1034466	7	1204	1034466	1017	0.845
	menhaden	0	0	0				0	0	0	0	0	0	0	
	monk	1	0	0	0	0	0	1	215	0	2	215	0	0	0.000
	pelagics							0	0	0	0	0	0	0	
	prin ground	84	4612	2697424	1	0	0	30	16808	70395658	115	21420	73093082	8549	0.399
	scupSeaBa	0	0	0	0	0	0	8	4792	4705811	8	4792	4705811	2169	0.453
	skates	0	0	0	0	0	0	10	134	8492	10	134	8492	92	0.687
	smallmesh	0	0	0	0	0	0	29	1286	258634	29	1286	258634	509	0.396
	squidbutter	0	0	0	0	0	0	15	36016	1666581822	15	36016	1666581822	40824	1.134
1990 Total		118	5967	2935191	1	0	0	143	83600	1766954920	262	89567	1769890111	42070	0.470

1991	AtlHerring	3	32	1229				2	294	0	5	326	1229	35	0.108
	crustacean	0	0	0	0	0	0	6	0	0	6	0	0	0	0.798
	dogfish	163	1589	515108	0	0	0	7	14367	71710917	170	15956	72226025	8499	0.533
	flatfish	87	592	41738	0	0	0	52	9211	26972910	139	9803	27014648	5198	0.530
	fluke 4spo	0	0	0	0	0	0	24	4564	2206170	24	4564	2206170	1485	0.325
	mackerel	2	0	0	0	0	0	2	3342	29134132	4	3342	29134132	5398	1.615
	menhaden	3	15	278				0	0	0	3	15	278	17	1.112
	monk	51	469	4399	0	0	0	13	1192	883693	64	1661	888092	942	0.567
	pelagics							1	0	0	1	0	0	0	
	prin ground	777	8334	1153238	35	1367	528324	45	10178	9644328	857	19879	11325889	3365	0.169
	scupSeaBa	0	0	0	0	0	0	4	29532	503848575	4	29532	503848575	22447	0.760
	skates	2	94	0	0	0	0	12	622	70781	14	716	70781	266	0.371
	smallmesh	0	0	0	2	0	0	54	946	106723	56	946	106723	327	0.345
	squidbutter	0	0	0				42	2944	2510440	42	2944	2510440	1584	0.538
1991 Total		1088	11125	1715989	37	1367	528324	264	77193	647088669	1389	89685	649332981	25482	0.284
1992	AtlHerring	0	0	0				1	0	0	1	0	0	0	
	crustacean	3	0	0				10	0	0	13	0	0	0	0.061
	dogfish	162	3492	6365059	0	0	0	2	1857	323261	164	5349	6688320	2586	0.483
	flatfish	104	73	3089	0	0	0	11	743	444048	115	816	447138	669	0.820
	fluke 4spo	0	0	0	0	0	0	14	2154	224194	14	2154	224194	473	0.220
	mackerel	13	2	2	0	0	0	3	594	99914	16	596	99916	316	0.530
	menhaden	0	0	0				0	0	0	0	0	0	0	
	monk	52	96	606	0	0	0	5	1	1	57	96	607	25	0.256
	pelagics							0	0	0	0	0	0	0	
	prin ground	773	4002	192509	0	0	0	27	6398	14188876	800	10400	14381385	3792	0.365
	scupSeaBa	1	2	0	0	0	0	0	0	0	1	2	0	0	0.000
	skates	3	24	0	0	0	0	7	11230	25018475	10	11253	25018475	5002	0.444
	smallmesh	1	0	0	0	0	0	46	1506	549887	47	1506	549887	742	0.493
	squidbutter	0	0	0	0	0	0	16	4571	3501286	16	4571	3501286	1871	0.409
1992 Total		1112	7691	6561265	0	0	0	142	29053	44349944	1254	36744	50911208	7135	0.194
1993	AtlHerring	0	0	0	0	0	0	4	0	0	4	0	0	0	
	crustacean	7	0	0				5	233	90907	12	234	90907	302	1.290
	dogfish	118	1962	257956	0	0	0	4	383	3010	122	2345	260966	511	0.218
	flatfish	91	18	48	0	0	0	14	1302	790364	105	1320	790413	889	0.674
	fluke 4spo	0	0	0	0	0	0	15	1201	253507	15	1201	253507	503	0.419
	mackerel	7	1	0	0	0	0	2	66	2154	9	67	2154	46	0.693
	menhaden	2	47	4159				0	0	0	2	47	4159	64	1.368
	monk	54	626	326733	0	0	0	5	616	12	59	1242	326745	572	0.460
	pelagics	1	0	0							1	0	0	0	
	prin ground	459	2902	282835	0	0	0	25	2754	1310655	484	5657	1593490	1262	0.223
	scupSeaBa	0	0	0	0	0	0	4	8851	78590488	4	8851	78590488	8865	1.002
	skates	7	14	26	0	0	0	7	42	120	14	56	146	12	0.216
	smallmesh	0	0	0	0	0	0	31	914	138157	31	914	138157	372	0.406
	squidbutter	0	0	0	0	0	0	16	2254	1058246	16	2254	1058246	1029	0.456
1993 Total		746	5571	871758	0	0	0	132	18618	82237620	878	24188	83109378	9116	0.377
1994	AtlHerring	2	10	12	0	0	0	0	0	0	2	10	12	3	0.333
	crustacean	10	0	0	0	0	0	7	2	1	17	2	1	1	0.666
	dogfish	317	754	8923	0	0	0	5	2010	506037	322	2764	514960	718	0.260
	flatfish	164	0	0	0	0	0	13	785	656711	177	785	656711	810	1.033
	fluke 4spo	0	0	0	0	0	0	22	1219	365002	22	1219	365002	604	0.496
	mackerel	5	57	683	0	0	0	0	0	0	5	57	683	26	0.459
	menhaden	6	0	0				0	0	0	6	0	0	0	
	monk	151	254	27179	0	0	0	11	24	176	162	278	27354	165	0.595
	pelagics	10	0	0				0	0	0	10	0	0	0	
	prin ground	647	74	573	3	204	4604	20	1490	373392	670	1767	378569	615	0.348
	scupSeaBa	0	0	0	0	0	0	1	1632	0	1	1632	0	0	0.000
	skates	18	86	4984	0	0	0	3	2357	7527849	21	2443	7532833	2745	1.123
	smallmesh	1	0	0	0	0	0	1	50	0	2	50	0	0	0.000
	squidbutter	0	0	0	0	0	0	12	6384	7269159	12	6384	7269159	2696	0.422
1994 Total		1331	1235	42353	3	204	4604	95	15952	16698326	1429	17390	16745284	4092	0.235

1995	AtlHerring	2	0	0				9	162	7154	11	162	7154	85	0.522
	crustacean	6	2	0				20	0	0	26	2	0	0	0.004
	dogfish	344	1366	90874	1	646	0	10	2879	480116	355	4891	570990	756	0.154
	flatfish	135	1	1	0	0	0	18	869	171599	153	871	171600	414	0.476
	fluke 4spo	0	0	0	0	0	0	36	1412	774916	36	1412	774916	880	0.623
	mackerel	3	5	0	0	0	0	4	177	51375	7	182	51375	227	1.246
	menhaden	8	0	0				0	0	0	8	0	0	0	
	monk	135	59	298	0	0	0	5	78	380	140	137	678	26	0.190
	pelagics	8	0	0				1	0	0	9	0	0	0	0.010
	prin ground	400	778	169578	0	0	0	15	3190	1271917	415	3968	1441495	1201	0.303
	scupSeaBa	0	0	0	0	0	0	3	1286	338140	3	1286	338140	581	0.452
	skates	17	37	485	0	0	0	14	725	453343	31	762	453828	674	0.884
	smallmesh	0	0	0	0	0	0	31	1400	1465986	31	1400	1465986	1211	0.865
	squidbutter	0	0	0	0	0	0	39	5298	9808040	39	5298	9808040	3132	0.591
1995 Total		1058	2248	261235	1	646	0	205	17477	14822966	1264	20371	15084202	3884	0.191
1996	AtlHerring	2	0	0				4	0	0	6	0	0	0	
	crustacean	4	23	2092	0	0	0	11	2	1	15	25	2093	46	1.826
	dogfish	276	1024	84441	0	0	0	8	1372	702466	284	2396	786907	887	0.370
	flatfish	171	0	0	0	0	0	24	266	10049	195	266	10049	100	0.377
	fluke 4spo	0	0	0	0	0	0	20	377	123123	20	377	123123	351	0.930
	mackerel	11	6	14	0	0	0	4	120	5908	15	126	5921	77	0.609
	menhaden	9	1	1				0	0	0	9	1	1	1	0.677
	monk	136	43	192	0	0	0	4	10210	3957	140	10253	4149	64	0.006
	pelagics	2	0	0				1	144	0	3	144	0	0	0.000
	prin ground	368	210	5621	1	0	0	13	4049	3221429	382	4259	3227050	1796	0.422
	scupSeaBa	0	0	0	0	0	0	4	8	41	4	8	41	6	0.818
	skates	19	20	132	0	0	0	11	6513	2952982	30	6534	2953114	1718	0.263
	smallmesh	0	0	0	0	0	0	59	2414	2306379	59	2414	2306379	1519	0.629
	squidbutter	0	0	0	0	0	0	48	742	258365	48	742	258365	508	0.685
1996 Total		998	1327	92493	1	0	0	211	26218	9584699	1210	27545	9677192	3111	0.113
1997	AtlHerring	0	0	0	0	0	0	0	0	0	0	0	0	0	
	crustacean	2	0	0	0	0	0	0	0	0	2	0	0	0	
	dogfish	319	296	2881	0	0	0	0	0	0	319	296	2881	54	0.181
	flatfish	118	1	0	0	0	0	7	8298	66397466	125	8298	66397466	8148	0.982
	fluke 4spo	6	0	0	0	0	0	10	609	66045	16	609	66045	257	0.422
	mackerel	14	4	2	0	0	0	0	0	0	14	4	2	1	0.335
	menhaden	11	0	0				0	0	0	11	0	0	0	0.592
	monk	161	78	307	0	0	0	2	435	0	163	513	307	18	0.034
	pelagics	6	0	0				0	0	0	6	0	0	0	1.242
	prin ground	276	43	178	0	0	0	7	549	21842	283	592	22019	148	0.251
	scupSeaBa	0	0	0	0	0	0	0	0	0	0	0	0	0	
	skates	24	3	4	0	0	0	0	0	0	24	3	4	2	0.606
	smallmesh	0	0	0	0	0	0	2	1057	1081436	2	1057	1081436	1040	0.984
	squidbutter	2	0	0	0	0	0	52	1000	761812	54	1000	761812	873	0.873
1997 Total		939	425	3371	0	0	0	80	11947	68328600	1019	12371	68331971	8266	0.668
1998	AtlHerring	0	0	0				0	0	0	0	0	0	0	
	crustacean	2	0	0	0	0	0	0	0	0	2	0	0	0	
	dogfish	405	222	5588	0	0	0	7	1393	294616	412	1615	300204	548	0.339
	flatfish	42	15	200	0	0	0	5	2833	80	47	2848	280	17	0.006
	fluke 4spo	2	0	0	0	0	0	11	644	103367	13	644	103367	322	0.499
	mackerel	11	1	1	0	0	0	2	0	0	13	1	1	1	0.842
	menhaden	30	15	178				0	0	0	30	15	178	13	0.900
	monk	158	22	42	0	0	0	0	0	0	158	22	42	7	0.291
	pelagics	12	0	0				0	0	0	12	0	0	0	
	prin ground	198	128	3486	0	0	0	1	241	0	199	369	3486	59	0.160
	scupSeaBa	0	0	0	0	0	0	0	0	0	0	0	0	0	
	skates	19	18	179	0	0	0	3	0	0	22	18	179	13	0.743
	smallmesh	0	0	0	0	0	0	10	2618	4421416	10	2618	4421416	2103	0.803
	squidbutter	0	0	0	0	0	0	19	261	17507	19	261	17507	132	0.506
1998 Total		879	421	9675	0	0	0	58	7990	4836985	937	8411	4846660	2202	0.262

	crustacean	3	0	0	0	0	0	0	0	0	3	0	0	0	
	dogfish	258	103	644	0	0	0	3	0	0	261	103	644	25	0.246
	flatfish	84	2	1	0	0	0	45	3165	1643228	129	3167	1643230	1282	0.405
	fluke 4spo	7	0	0	0	0	0	22	422	38244	29	422	38244	196	0.463
	mackerel	7	0	0	0	0	0	6	18	148	13	18	148	12	0.674
	menhaden	18	0	0				0	0	0	18	0	0	0	
	monk	103	24	107	0	0	0	6	613	136899	109	638	137006	370	0.581
	pelagics	16	0	0				0	0	0	16	0	0	0	
	prin ground	220	304	14894	0	0	0	14	707	79116	234	1011	94010	307	0.303
	scupSeaB	0	0	0	0	0	0	2	67	306	2	67	306	17	0.259
	skates	26	11	58	0	0	0	1	0	0	27	11	58	8	0.668
	smallmesh	0	0	0	0	0	0	20	1207	330960	20	1207	330960	575	0.477
	squidbutter	1	0	0	0	0	0	47	558	55659	48	558	55659	236	0.423
1999 Total		747	444	15704	0	0	0	166	6758	2284560	913	7203	2300264	1517	0.211
2000	AtlHerring	0	0	0				3	0	0	3	0	0	0	1.142
	crustacean	4	0	0				1	45	0	5	45	0	0	0.000
	dogfish	79	42	453	4	171	2366	1	0	0	84	214	2820	53	0.249
	flatfish	78	1	0	0	0	0	85	493	32433	163	494	32433	180	0.365
	fluke 4spo	1	0	0	0	0	0	21	552	96014	22	552	96014	310	0.562
	mackerel	11	2	2	0	0	0	6	1	1	17	3	3	2	0.472
	menhaden	24	3	4				0	0	0	24	3	4	2	0.752
	monk	234	59	608	0	0	0	3	140	5856	237	199	6464	80	0.404
	pelagics	16	0	0				0	0	0	16	0	0	0	
	prin ground	373	913	97966	0	0	0	48	1128	251967	421	2041	349933	592	0.290
	scupSeaB	0	0	0	0	0	0	4	2	1	4	2	1	1	0.480
	skates	25	61	3660	0	0	0	20	100	3171	45	161	6831	83	0.513
	smallmesh	1	147	0	0	0	0	19	2123	650697	20	2270	650697	807	0.355
	squidbutter	3	0	0				45	934	151382	48	934	151382	389	0.417
2000 Total		849	1228	102694	4	171	2366	256	5518	1191521	1109	6917	1296582	1139	0.165
2001	AtlHerring	0	0	0				0	0	0	0	0	0	0	
	crustacean	0	0	0				29	0	0	29	0	0	0	
	dogfish	52	22	213	0	0	0	0	0	0	52	22	213	15	0.668
	flatfish	46	0	0	0	0	0	69	1681	103480	115	1681	103480	322	0.191
	fluke 4spo	17	0	0	0	0	0	27	336	21242	44	336	21242	146	0.433
	mackerel	2	0	0	0	0	0	1	3	0	3	3	0	0	0.000
	menhaden	16	1	0				0	0	0	16	1	0	0	0.766
	monk	151	87	1848	0	0	0	4	2023	857256	155	2110	859104	927	0.439
	pelagics	3	0	0				0	0	0	3	0	0	0	0.736
	prin ground	249	852	83232	0	0	0	71	2291	313742	320	3144	396975	630	0.200
	scupSeaB	0	0	0	0	0	0	5	67	4205	5	67	4205	65	0.975
	skates	39	32	367	0	0	0	3	752	20	42	784	387	20	0.025
	smallmesh	1	12	0	0	0	0	20	3388	7307464	21	3400	7307464	2703	0.795
	squidbutter	2	0	0	0	0	0	38	1924	217778	40	1924	217778	467	0.243
2001 Total		578	1005	85661	0	0	0	267	12465	8825188	845	13471	8910849	2985	0.222
2002	AtlHerring	0	0	0				0	0	0	0	0	0	0	
	crustacean	0	0	0	0	0	0	29	0	0	29	0	0	0	
	dogfish	24	30	624	0	0	0	0	0	0	24	30	624	25	0.819
	flatfish	20	56	656	0	0	0	145	564	13249	165	620	13905	118	0.190
	fluke 4spo	17	0	0	0	0	0	23	321	220452	40	321	220452	470	1.462
	mackerel	0	0	0	0	0	0	0	0	0	0	0	0	0	
	menhaden	3	0	0				0	0	0	3	0	0	0	
	monk	87	138	3956	0	0	0	19	440	44352	106	578	48308	220	0.380
	pelagics	0	0	0				1	0	0	1	0	0	0	
	prin ground	203	899	58180	9	1789	1710096	101	1160	174950	313	3848	1943226	1394	0.362
	scupSeaB	0	0	0	0	0	0	1	207	0	1	207	0	0	0.000
	skates	26	606	124973	0	0	0	15	1500	1082050	41	2106	1207023	1099	0.522
	smallmesh	0	0	0	0	0	0	20	422	11632	20	422	11632	108	0.256
	squidbutter	0	0	0				28	1858	737921	28	1858	737921	859	0.462
2002 Total		380	1730	188390	9	1789	1710096	382	6471	2284606	771	9990	4183092	2045	0.205
Grand Total		10964	47143	15454089	56	4177	2245390	2617	429268	2790322573	13637	480588	2808022052	52991	0.110

Table B4.10. Summary of catch-based ratio estimates of dogfish discards by gear group and fishing year. All species groups included.

	gillnet			hook			trawl			Gill net + Hook + Trawl				
Fishing Year	Sum of Ntrips	Sum of Total Discards in mt gillnet	SE of Total Discards	Sum of Ntrips	Sum of Total Discards in mt Hook	SE of Total Discards	Sum of Ntrips	Sum of Total Discards in mt Trawl	SE of Total Discards	Total Sum of Ntrips	Total Sum of Total Discards in mt	SE of Total Discards	CV total	USA+ Canada+ Recreational Landings
1988	0	0	0	0	0	0	34	66498	3951	34	66498	3951	0.059	4987
1989	141	6727	1603	0	0	0	182	43509	10258	323	50236	10382	0.207	6676
1990	118	5967	1713	1	0	0	143	83600	42035	262	89567	42070	0.470	17788
1991	1088	11125	1310	37	1367	727	264	77193	25438	1389	89685	25482	0.284	15183
1992	1112	7691	2561	0	0	0	142	29053	6660	1254	36744	7135	0.194	18987
1993	746	5571	934	0	0	0	132	18618	9068	878	24188	9116	0.377	23311
1994	1331	1235	206	3	204	68	95	15952	4086	1429	17390	4092	0.235	21744
1995	1058	2248	511	1	646	0	205	17477	3850	1264	20371	3884	0.191	24365
1996	998	1327	304	1	0	0	211	26218	3096	1210	27545	3111	0.113	28279
1997	939	425	58	0	0	0	80	11947	8266	1019	12371	8266	0.668	19825
1998	879	421	98	0	0	0	58	7990	2199	937	8411	2202	0.262	22962
1999	747	444	125	0	0	0	166	6758	1511	913	7203	1517	0.211	18466
2000	849	1228	320	4	171	49	256	5518	1092	1109	6917	1139	0.165	13036
2001	578	1005	293	0	0	0	267	12465	2971	845	13471	2985	0.222	8468
2002	380	1730	434	9	1789	1308	382	6471	1511	771	9990	2045	0.205	7518
Grand Tota	10964	47143	3931	56	4177	1498	2617	429268	52824	13637	480588	52991	0.110	

Table B4.11. Projected dead discards of spiny dogfish by fishing year. Fraction dead by gear type= 0.75 gill nets, 0.50 trawls, 0.25 Hook gear.
Standard error computation assumes that coefficient of variation remains constant.

	Gill Net			Hook			Trawl			Gill net + Hook + Trawl			
Fishing Year	Sum of Trips	Dead Discards (mt)	SE (mt)	Sum of Trips	Dead Discards (mt)	SE (mt)	Sum of Trips	Dead Discards (mt)	SE (mt)	Sum of Trips	Dead Discards (mt)	SE (mt)	CV
1988	0	0	0	0	0	0	34	33249	1975	34	33249	1975	0.059
1989	141	5045	1202	0	0	0	182	21755	5129	323	26800	5268	0.197
1990	118	4475	1285	1	0	0	143	41800	21018	262	46275	21057	0.455
1991	1088	8344	982	37	342	182	264	38596	12719	1389	47282	12758	0.270
1992	1112	5768	1921	0	0	0	142	14527	3330	1254	20294	3844	0.189
1993	746	4178	700	0	0	0	132	9309	4534	878	13487	4588	0.340
1994	1331	926	154	3	51	17	95	7976	2043	1429	8953	2049	0.229
1995	1058	1686	383	1	162	0	205	8738	1925	1264	10586	1963	0.185
1996	998	995	228	1	0	0	211	13109	1548	1210	14104	1565	0.111
1997	939	318	44	0	0	0	80	5973	4133	1019	6292	4133	0.657
1998	879	316	74	0	0	0	58	3995	1100	937	4311	1102	0.256
1999	747	333	94	0	0	0	166	3379	756	913	3713	762	0.205
2000	849	921	240	4	43	12	256	2759	546	1109	3723	596	0.160
2001	578	754	220	0	0	0	267	6233	1485	845	6987	1501	0.215
2002	380	1298	326	9	447	327	382	3236	756	771	4981	885	0.178
Grand Tota	10964	35358		56	1044		2617	214634		13637	251036	64047	

mean	16736
min	3713
max	47282

Table B4.12. Sum of discard estimates (mt) based on trip ratio method.

Year	Dredge	Other	Shrimp Trawls	Hook Gear	Gill Nets	Trawls	Gill Net + Trawl	All Gear	USA Comm Landings (mt)	USA+ Canada+ Recreational
1989	0	0	19	0	6557	27283	33840	33859	4491	6676
1990	0	0	0	0	3495	43181	46676	46676	14742	17788
1991	728	26	3	1580	11984	35497	47481	49818	13154	15183
1992	2310	6763	0	1651	4278	53037	57315	68039	16874	18987
1993	1452	21	0	7	5443	31465	36907	38388	21228	23311
1994	3283	4	23	59	905	66885	67790	71159	18779	21744
1995	1553	135	6	699	1642	28816	30458	32851	21591	24365
1996	605	0	0	0	1464	15859	17324	17929	26944	28279
1997	1177	116	0	0	1489	28072	29561	30854	20412	19825
1998	497	27	0	0	889	23777	24666	25189	21500	22962
1999	107	497	0	0	545	8942	9487	10091	15377	18466
2000	770	19599	0	1249	1305	8563	9869	31487	9571	13036
2001	801	9001	0	0	1051	10494	11544	21347	2294	8468
2002	158	21783	0	5344	1639	10146	11785	39071	2136	7518

Table B4.13. Summary of total number of trips by commercial fishing vessels by year.

Sum of NTRIPS	GearName						
YEAR2	dredge	gillnet	hook	other	shrimptrawl	trawl	Grand Total
1989	23,463	16,081	3,674	23,880	9,113	35,987	112,198
1990	26,266	17,483	4,410	28,955	8,971	35,540	121,624
1991	28,710	18,549	6,340	31,006	7,227	36,997	128,829
1992	28,353	18,833	6,031	30,063	7,119	36,857	127,256
1993	27,908	25,209	5,493	40,432	5,864	37,473	142,379
1994	19,740	30,088	5,486	53,211	7,222	41,803	157,550
1995	14,905	29,196	6,921	53,920	10,309	45,885	161,136
1996	17,808	36,404	4,466	58,235	12,345	47,048	176,306
1997	20,915	50,321	5,236	91,492	13,127	47,274	228,366
1998	21,767	41,248	5,773	89,748	8,330	51,409	218,276
1999	14,051	30,263	3,463	67,436	4,970	33,524	153,707
2000	70,813	34,795	3,687	82,465	6,909	46,906	245,575
2001	78,528	31,104	3,922	79,769	3,617	47,940	244,880
2002	11,125	34,771	3,389	85,605	2,444	45,989	183,323
Grand Total	404,352	414,345	68,291	816,217	107,568	590,632	2,401,405

Table B5.1. Stratified mean number per tow indices for spiny dogfish from NEFSC spring (1968-2000) and autumn (1967-1999) bottom trawl surveys (offshore strata 1-30, 33-40, 61-76; Footnotes A-D).

	Spring				Autumn			
	Unsexed	Male	Female	Total	Unsexed	Male	Female	Total
1967					34.0			34.0
1968	24.3			24.3	19.7			19.7
1969	13.3			13.3	27.7			27.7
1970	15.3			15.3	16.6			16.6
1971	15.9			15.9	12.9			12.9
1972	27.6			27.6	10.5			10.5
1973	35.6			35.6	15.0			15.0
1974	39.1			39.1	4.7			4.7
1975	35.4			35.4	17.7			17.7
1976	23.1			23.1	14.9			14.9
1977	13.1			13.1	6.8			6.8
1978	22.5			22.5	26.0			26.0
1979	10.1			10.1	22.0			22.0
1980	6.1	12.9	10.0	29.0	0.0	1.4	3.8	5.1
1981	0.5	18.2	23.0	41.7	0.0	36.0	39.7	75.7
1982		23.7	27.8	51.6		6.9	6.8	13.7
1983	0.0	23.6	18.1	41.7	0.0	14.3	18.0	32.4
1984		13.3	9.2	22.5		10.6	11.9	22.5
1985	0.0	80.2	37.1	117.3	0.0	19.0	19.7	38.7
1986		9.5	19.3	28.7		12.3	15.2	27.4
1987		39.3	25.8	65.1		16.5	16.3	32.8
1988	0.0	29.5	35.1	64.6		15.5	19.9	35.3
1989		29.6	27.1	56.7		6.7	6.0	12.8
1990		47.8	44.0	91.8		14.7	11.5	26.1
1991		32.3	30.0	62.3		20.9	17.4	38.4
1992		38.2	41.3	79.5		12.9	26.2	39.1
1993		32.6	28.3	60.9		4.5	2.4	6.9
1994		53.4	38.1	91.5		16.6	14.2	30.9
1995		25.8	25.0	50.8		16.9	13.7	30.6
1996		52.6	44.6	97.3		12.8	20.1	32.8
1997		29.6	29.1	58.7		17.6	10.4	27.9
1998		32.4	11.1	43.5		8.8	13.2	22.0
1999		35.4	21.4	56.8		9.2	8.7	17.9
2000	0.3	22.2	15.4	37.9		17.1	5.7	22.8
2001		20.3	10.9	31.2		16.5	18.5	35.0
2002		32.2	18.7	50.9		15.8	15.4	31.2
2003		32.5	17.5	49.9				

A. During 1963-1984, BMV oval doors were used in the spring and autumn surveys; since 1985, Portuguese polyvalent doors have been used in both surveys. No adjustments have been made because no significant difference was found between the two types of doors for spiny dogfish (NEFSC 1991)

B. Spring surveys from 1973-1981 were accomplished with a '41 Yankee' trawl; in all other years, spring surveys were accomplished with a '36 Yankee' trawl. A factor of 0.71 was applied to all tows in these years (Sissenwine and Bowman, 1978).

C. During the fall of 1970, 1975, 1978, 1979, 1980, 1981, 1985, 1986, 1988, 1989 1990, 1991, and 1993 and the springs of 1973, 1976, 1977, 1979, 1980, 1981, 1982, 1987, 1989, 1990, 1991, and 1994 the Delaware II was used entirely or in part to conduct the survey. All other years, the Albatross IV was the only vessel used for the survey. A factor of 0.79 was applied to all Delaware II tows (NEFSC 1991).

D. During the spring of 2003, the Delaware II was used to conduct the survey. Since the vessel was remodeled in 1995, it was unclear whether the conversion factors applied in earlier years were still appropriate. Therefore no conversion factor was applied.

Table B5.2. Stratified mean weight per tow (kg) indices for spiny dogfish from NEFSC spring (1968-2002) and autumn (1967-2002) bottom trawl surveys (offshore strata 1-30, 33-40, 61-76; Footnotes A-E).

	Spring				Autumn			
	Unsexed	Male	Female	Total	Unsexed	Male	Female	Total
1967					34.9			34.9
1968	25.8			25.8	22.4			22.4
1969	16.1			16.1	55.3			55.3
1970	13.3			13.3	23.8			23.8
1971	24.0			24.0	15.5			15.5
1972	49.0			49.0	16.1			16.1
1973	57.1			57.1	21.7			21.7
1974	67.0			67.0	8.1			8.1
1975	45.6			45.6	20.9			20.9
1976	37.0			37.0	19.8			19.8
1977	24.1			24.1	16.1			16.1
1978	36.3			36.3	19.3			19.3
1979	13.4			13.4	26.6			26.6
1980	13.4	34.2	1.6	49.1	0.0	4.0	15.1	19.1
1981	0.6	20.4	48.2	69.2	0.0	12.7	34.9	47.6
1982		31.1	86.0	117.0		5.2	9.7	14.9
1983	0.0	21.1	17.7	38.9	0.0	13.7	22.1	35.8
1984		19.3	23.0	42.4		8.7	13.9	22.5
1985	0.0	100.4	66.7	167.1	0.0	14.6	25.0	39.7
1986		5.8	39.0	44.9		13.4	23.7	37.1
1987		40.6	61.7	102.3		10.6	11.2	21.8
1988	0.0	26.9	77.4	104.4		15.3	24.3	39.6
1989		34.8	43.1	77.8		6.1	5.5	11.5
1990		60.6	89.2	149.8		14.9	14.9	29.8
1991		36.5	53.0	89.5		24.6	26.7	51.3
1992		44.8	70.1	114.9		14.1	41.6	55.7
1993		35.7	52.2	87.9		5.1	2.1	7.2
1994		49.9	35.3	85.1		18.5	14.2	32.8
1995		34.8	40.0	74.8		16.7	11.4	28.0
1996		59.0	60.5	119.5		14.4	26.7	41.1
1997		37.5	44.9	82.4		19.9	10.0	29.9
1998		43.4	15.5	58.9		10.7	21.6	32.3
1999		46.3	32.5	78.8		12.3	12.7	25.1
2000	0.4	29.7	29.2	59.4		25.5	9.2	34.7
2001		29.5	19.8	49.3		20.8	27.0	47.8
2002		42.9	32.2	75.0		22.2	25.2	47.4
2003		45.2	29.7	74.8				

min fem sp	15.5
max fem s	89.2
mean fem	46.4

A. During 1963-1984, BMV oval doors were used in the spring and autumn surveys; since 1985, Portuguese polyvalent doors have been used in both surveys. No adjustments have been made because no significant difference was found between the two types of doors for spiny dogfish (NEFSC 1991)

B. Spring surveys from 1973-1981 were accomplished with a '41 Yankee' trawl; in all other years, spring surveys were accomplished with a '36 Yankee' trawl. A factor of 0.69 was applied to all tows in these years (Sissenwine and Bowman, 1978).

C. During the fall of 1970, 1975, 1978, 1979, 1980, 1981, 1985, 1986, 1988, 1989 1990, 1991, and 1993 and the springs of 1973, 1976, 1977, 1979, 1980, 1981, 1982, 1987, 1989, 1990, 1991, and 1994 the Delaware II was used entirely or in part to conduct the survey. All other years, the Albatross IV was the only vessel used for the survey. A factor of 0.81 was applied to all Delaware II tows (NEFSC 1991).

D. During the spring of 2003, the Delaware II was used to conduct the survey. Since the vessel was remodeled in 1995, it was unclear whether the conversion factors applied in earlier years were still appropriate. Therefore no conversion factor was applied.

E. In 1980, dogfish were often measured and counted by sex but only one weight recorded. This weight was always recorded under males.

Table B5.3. Indices for spiny dogfish from NEFSC winter (1992-2002)
(offshore strata 1-3, 5-7, 9-11, 13-14, 16, 61-63, 65-67, 69-71,73-75).

	Number/Tow			Weight/Tow		
	Male	Female	Total	Male	Female	Total
1992	123.9	74.7	198.7	168.3	172.6	340.9
1993	225.2	103.1	328.2	274.8	145.1	419.9
1994	154.9	153.1	308.1	169.8	219.7	389.5
1995	198.3	124.6	322.8	195.9	103.2	299.1
1996	87.6	48.3	135.9	116.2	76.1	192.2
1997	75.3	69.1	144.3	91.9	107.7	199.6
1998	76.1	43.5	119.6	101.6	62.8	164.4
1999	193.0	110.8	303.8	203.0	120.6	323.5
2000	102.1	39.6	141.7	129.8	53.6	183.4
2001	76.4	47.2	123.5	102.1	66.4	168.5
2002	144.3	65.4	209.7	192.7	115.3	308.1
2003	87.8	56.6	144.4	122.8	112.6	235.4

Table B5.4. Number per tow indices for spiny dogfish from the state of Massachusetts spring and autumn inshore bottom trawl surveys.

	Spring				Autumn			
	Unsexed	Male	Female	Total	Unsexed	Male	Female	Total
1978	10.9			10.9	149.1			149.1
1979	1.9			1.9	12.6			12.6
1980	1.7			1.7	0.0	0.1	4.7	4.8
1981	0.5		1.0	1.6	11.2	0.1	0.3	11.6
1982		0.0	2.0	2.0		8.2	45.9	54.1
1983		0.0	0.8	0.8		3.1	11.5	14.7
1984		1.4	5.5	6.9		51.1	17.4	68.5
1985		0.1	0.8	0.8		12.5	116.6	129.1
1986		0.1	2.2	2.2		45.2	77.9	123.1
1987		0.0	0.2	0.2		14.1	36.8	50.9
1988		1.5	11.5	12.9		34.0	181.9	215.9
1989		9.2	16.4	25.6		256.7	764.6	1021.3
1990			2.3	2.3		16.3	41.5	57.8
1991		0.0	0.9	0.9		2.8	25.6	28.4
1992			2.2	2.2		51.4	67.6	119.1
1993		9.4	10.5	19.8		15.8	93.9	109.7
1994			0.2	0.2		18.7	1.3	20.0
1995		7.5	21.2	28.6		40.0	33.1	73.1
1996		0.0	0.0	0.0		14.2	21.1	35.3
1997		2.1	11.1	13.2		9.5	46.4	55.9
1998		0.8	3.0	3.8		3.4	19.4	22.9
1999		0.3	4.1	4.3		8.4	55.8	64.2
2000		0.1	1.0	1.1		1.3	13.9	15.2
2001		1.5	4.1	5.6		22.8	77.7	100.5
2002		0.0	4.4	4.5		9.6	49.0	58.6

Table B5.5. Weight per tow (kg) indices for spiny dogfish from the state of Massachusetts spring and autumn inshore bottom trawl surveys.

	Spring				Autumn			
	Unsexed	Male	Female	Total	Unsexed	Male	Female	Total
1978	22.9			22.9	225.7			225.7
1979	6.4			6.4	40.2			40.2
1980	6.1			6.1	0.1	0.1	17.8	18.1
1981	2.6		4.3	6.9	44.9	0.2	1.3	46.4
1982		0.1	9.2	9.3		14.2	166.2	180.4
1983		0.0	3.2	3.3		5.0	35.6	40.6
1984		1.6	10.8	12.4		80.6	43.7	124.2
1985		0.1	3.4	3.5		18.0	297.5	315.5
1986		0.1	9.7	9.7		70.4	224.1	294.6
1987		0.0	0.9	0.9		20.9	105.3	126.2
1988		1.9	39.3	41.2		47.2	560.4	607.6
1989		4.8	14.0	18.9		328.9	1546.2	1875.1
1990			9.4	9.4		22.6	95.0	117.6
1991		0.0	4.5	4.5		3.4	80.7	84.1
1992			8.5	8.5		68.6	107.0	175.6
1993		10.4	19.5	29.9		23.3	211.7	235.0
1994			0.8	0.8		30.8	2.8	33.6
1995		9.5	34.1	43.7		59.6	63.6	123.2
1996		0.0	0.1	0.1		20.8	44.4	65.2
1997		2.4	20.5	22.9		13.5	87.2	100.7
1998		1.0	5.8	6.8		4.5	41.9	46.4
1999		0.4	8.5	8.8		12.9	116.0	128.9
2000		0.1	2.7	2.9		2.2	29.0	31.2
2001		2.4	9.3	11.7		31.2	157.8	189.0
2002		0.0	11.5	11.6		15.3	109.7	125.0

Table B6.1. Biomass estimates for spiny dogfish (thousands of metric tons) based on area swept by NEFSC trawl during spring surveys, 1968-2003.

Year	Lengths >= 80 cm			Lengths 36 to 79 cm			Length <= 35 cm			All Lengths
	Females	Males	Total	Females	Males	Total	Females	Males	Total	
1968			41.4			110.4			1.52	153.3
1969			27.4			69.3			0.66	97.3
1970			36.7			33.0			3.19	72.9
1971			103.8			27.6			2.76	134.2
1972			126.6			145.9			1.55	274.1
1973			178.7			165.3			2.58	346.5
1974			221.9			179.6			2.66	404.1
1975			105.1			125.0			3.97	234.0
1976			96.3			120.8			1.20	218.3
1977			77.3			68.0			0.53	145.9
1978			87.4			131.2			1.24	219.8
1979			52.3			18.6			1.82	72.7
1980	104.7	15.3	168.1	16.8	72.2	123.5	0.32	0.39	0.84	292.4
1981	266.5	24.4	293.8	25.5	75.1	100.6	2.14	2.80	5.06	399.5
1982	454.0	34.6	488.6	61.6	143.3	204.9	0.48	0.69	1.17	694.6
1983	77.7	30.1	107.8	36.7	98.5	135.3	3.09	3.95	7.03	250.1
1984	115.6	27.5	143.1	33.4	88.0	121.4	0.14	0.21	0.35	264.9
1985	317.0	125.5	442.6	102.5	502.5	605.0	4.01	5.10	9.10	1056.7
1986	191.3	3.5	194.8	51.9	29.6	81.5	0.84	1.11	1.96	278.2
1987	219.1	90.5	309.6	61.5	171.7	233.1	2.46	4.76	7.22	550.0
1988	433.1	26.2	459.4	93.3	153.6	247.0	0.89	1.09	1.98	708.4
1989	162.1	40.5	202.6	100.4	158.2	258.6	1.14	1.54	2.68	463.9
1990	400.3	70.7	471.0	163.5	303.1	466.6	0.68	1.03	1.71	939.3
1991	220.4	30.0	250.3	108.4	186.3	294.7	0.98	1.43	2.41	547.4
1992	280.5	41.9	322.4	179.9	231.9	411.8	0.73	1.00	1.73	735.9
1993	234.6	27.8	262.5	104.1	198.5	302.6	0.55	0.65	1.21	566.3
1994	105.3	37.1	142.4	108.3	254.2	362.5	4.28	5.54	9.82	514.8
1995	102.4	29.5	131.9	154.0	174.5	328.5	0.25	0.35	0.59	460.9
1996	196.5	33.4	229.9	201.7	334.8	536.4	0.98	1.14	2.12	768.5
1997	83.7	17.5	101.2	205.2	209.1	414.3	0.05	0.05	0.10	515.5
1998	26.7	22.9	49.7	69.0	236.4	305.4	0.05	0.08	0.13	355.2
1999	62.7	20.4	83.1	140.8	256.4	397.2	0.02	0.03	0.05	480.4
2000	85.8	11.7	97.5	91.5	166.2	257.7	0.07	0.09	0.16	355.4
2001	56.7	16.7	73.4	71.4	160.5	231.9	0.04	0.03	0.07	305.4
2002	75.2	19.0	94.2	131.5	246.3	377.8	0.06	0.06	0.12	472.1
2003	64.5	22.5	87.1	125.5	256.3	381.8	0.13	0.14	0.27	469.1

Notes: Total equals sum of males and females plus unsexed dogfish. Data for dogfish prior to 1980 are currently not available by sex.

Table B6.2. Biomass estimates for spiny dogfish (thousands of metric tons) based on area swept by NEFSC trawl during spring surveys, 1968-2003, adjusted for 0.012 nm sqr footprint.

Year	Lengths >= 80 cm			Lengths 36 to 79 cm			Length <= 35 cm			All Lengths
	Females	Males	Total	Females	Males	Total	Females	Males	Total	
1968			34.5			92.0			1.26	127.8
1969			22.8			57.8			0.55	81.1
1970			30.6			27.5			2.66	60.8
1971			86.5			23.0			2.30	111.8
1972			105.5			121.6			1.29	228.4
1973			148.9			137.7			2.15	288.8
1974			184.9			149.7			2.22	336.8
1975			87.6			104.1			3.31	195.0
1976			80.3			100.7			1.00	181.9
1977			64.4			56.7			0.44	121.6
1978			72.8			109.3			1.04	183.2
1979			43.6			15.5			1.52	60.6
1980	87.2	12.7	140.1	14.0	60.2	102.9	0.27	0.33	0.70	243.7
1981	222.1	20.3	244.8	21.2	62.6	83.9	1.78	2.33	4.21	332.9
1982	378.3	28.8	407.1	51.3	119.4	170.7	0.40	0.57	0.97	578.8
1983	64.8	25.1	89.8	30.6	82.1	112.7	2.57	3.29	5.86	208.4
1984	96.3	22.9	119.3	27.9	73.3	101.2	0.11	0.18	0.29	220.7
1985	264.2	104.6	368.8	85.4	418.8	504.2	3.34	4.25	7.58	880.6
1986	159.4	3.0	162.3	43.2	24.6	67.9	0.70	0.93	1.63	231.8
1987	182.6	75.4	258.0	51.2	143.0	194.3	2.05	3.97	6.02	458.3
1988	361.0	21.8	382.9	77.8	128.0	205.8	0.74	0.91	1.65	590.4
1989	135.1	33.7	168.8	83.7	131.9	215.5	0.95	1.28	2.24	386.6
1990	333.6	58.9	392.5	136.2	252.6	388.8	0.57	0.86	1.43	782.7
1991	183.6	25.0	208.6	90.4	155.2	245.6	0.81	1.19	2.00	456.2
1992	233.8	34.9	268.6	149.9	193.2	343.2	0.61	0.83	1.44	613.2
1993	195.5	23.2	218.7	86.8	165.4	252.2	0.46	0.54	1.00	471.9
1994	87.8	30.9	118.7	90.2	211.9	302.1	3.57	4.62	8.19	429.0
1995	85.4	24.5	109.9	128.3	145.4	273.7	0.21	0.29	0.49	384.1
1996	163.7	27.8	191.6	168.1	279.0	447.0	0.82	0.95	1.77	640.4
1997	69.7	14.6	84.3	171.0	174.2	345.2	0.04	0.04	0.08	429.6
1998	22.3	19.1	41.4	57.5	197.0	254.5	0.04	0.06	0.11	296.0
1999	52.2	17.0	69.3	117.4	213.6	331.0	0.01	0.03	0.04	400.3
2000	71.5	9.7	85.9	76.2	138.5	214.8	0.06	0.07	0.13	300.9
2001	47.2	14.0	61.2	59.5	133.7	193.3	0.04	0.03	0.06	254.5
2002	62.6	15.8	78.5	109.5	205.3	314.8	0.05	0.05	0.10	393.4
2003	53.8	18.8	72.5	104.6	213.6	318.1	0.11	0.12	0.23	390.9

Notes: Total equals sum of males and females plus unsexed dogfish. Data for dogfish prior to 1980 are currently not available by sex.

Table B6.3. Number of female spiny dogfish examined by year and season
(T = total number examined, FE = Number with free embryos).

		1998	1999	2000	2001	2002	Total
Winter	T	246	552	497	726	301	2322
	FE	59	132	84	110	42	427
Spring	T	283	926	786	582	557	3134
	FE	60	167	96	69	70	462
Autumn	T	391	505	416	713		2025
	FE	115	162	51	73		401
Total	T	920	1983	1699	2021	858	7481
	FE	234	461	231	252	112	1291

Table B7.1 Summary of 3yr moving average survey mean numbers per tow and SE for female and male dogfish caught in the NEFSC spring survey.
All offshore strata included.

<<<<<FEMALES>>>>>

Spring data All offshore strata

Sex	*year*	*mean*	*variance*	*SE*	*CV*	*Pop Var*	*Pop*	*Var(pop)*	*Low CI*	*High CI*	*3-yrMean*	*3-yrVar*	*3-yr SE*	*3-yrCV*
Females	1980	10.015	5.04E+00	2.25E+00	22.4	2.00E+03	6.49E+07	2.11E+14	5.615	14.415				
Females	1981	22.993	2.24E+01	4.74E+00	20.6	1.81E+04	1.49E+08	9.36E+14	13.71	32.275				
Females	1982	27.845	8.65E+01	9.30E+00	33.4	2.83E+04	1.80E+08	3.63E+15	9.617	46.074	20.28433	3.80E+01	6.163497	30.38551
Females	1983	18.075	1.70E+01	4.13E+00	22.8	1.34E+04	1.17E+08	7.15E+14	9.986	26.164	22.971	4.20E+01	6.479686	28.20812
Females	1984	9.155	3.13E+00	1.77E+00	19.3	1.19E+03	5.93E+07	1.31E+14	5.689	12.62	18.35833	3.56E+01	5.962519	32.47854
Females	1985	37.114	1.21E+02	1.10E+01	29.6	3.37E+04	2.40E+08	5.08E+15	15.552	58.675	21.448	4.71E+01	6.860002	31.98435
Females	1986	19.256	9.12E+00	3.02E+00	15.7	5.16E+03	1.25E+08	3.83E+14	13.335	25.176	21.84167	4.44E+01	6.665103	30.51554
Females	1987	25.824	4.15E+01	6.44E+00	24.9	1.27E+04	1.66E+08	1.71E+15	13.203	38.444	27.398	5.72E+01	7.563198	27.60493
Females	1988	35.095	1.06E+02	1.03E+01	29.4	3.01E+04	2.25E+08	4.36E+15	14.905	55.286	26.725	5.22E+01	7.227399	27.04359
Females	1989	27.115	2.77E+01	5.26E+00	19.4	2.36E+04	1.72E+08	1.11E+15	16.801	37.429	29.34467	5.84E+01	7.643559	26.04752
Females	1990	44.008	1.93E+02	1.39E+01	31.6	6.94E+04	2.82E+08	7.91E+15	16.781	71.234	35.406	1.09E+02	10.43665	29.47707
Females	1991	29.994	3.07E+01	5.54E+00	18.5	1.05E+04	1.93E+08	1.26E+15	19.141	40.848	33.70567	8.38E+01	9.152686	27.15474
Females	1992	41.305	1.01E+02	1.01E+01	24.4	2.44E+04	2.58E+08	3.96E+15	21.583	61.027	38.43567	1.08E+02	10.40631	27.07462
Females	1993	28.33	2.22E+01	4.72E+00	16.6	7.01E+03	1.81E+08	9.10E+14	19.087	37.573	33.20967	5.14E+01	7.168263	21.58487
Females	1994	38.115	4.39E+01	6.63E+00	17.4	3.54E+04	2.44E+08	1.80E+15	25.124	51.105	35.91667	5.58E+01	7.470252	20.79885
Females	1995	25.032	3.29E+01	5.73E+00	22.9	7.88E+03	1.61E+08	1.36E+15	13.794	36.27	30.49233	3.30E+01	5.745723	18.84317
Females	1996	44.625	2.86E+02	1.69E+01	37.9	9.13E+04	2.87E+08	1.18E+16	11.466	77.785	35.924	1.21E+02	11.00033	30.62113
Females	1997	29.058	2.22E+01	4.72E+00	16.2	6.06E+03	1.86E+08	9.09E+14	19.815	38.3	32.905	1.14E+02	10.66666	32.41654
Females	1998	11.143	5.45E+00	2.33E+00	20.9	1.41E+03	7.15E+07	2.24E+14	6.569	15.717	28.27533	1.05E+02	10.22909	36.17674
Females	1999	21.351	1.10E+01	3.32E+00	15.6	3.37E+03	1.34E+08	4.35E+14	14.839	27.862	20.51733	1.29E+01	3.592585	17.51
Females	2000	15.421	2.42E+01	4.92E+00	31.9	5.20E+03	9.90E+07	9.99E+14	5.771	25.07	15.97167	1.36E+01	3.684291	23.06767
Females	2001	10.884	1.39E+01	3.73E+00	34.2	3.18E+03	6.99E+07	5.73E+14	3.578	18.19	15.88533	1.64E+01	4.048456	25.4855
Females	2002	18.769	1.54E+01	3.92E+00	20.9	9.28E+03	1.21E+08	6.34E+14	11.084	26.454	15.02467	1.78E+01	4.223269	28.1089
Females	2003	17.474	5.86E+00	2.42E+00	13.9	9.30E+03	1.12E+08	2.42E+14	12.73	22.218	15.709	1.17E+01	3.421905	21.78309

Sex	***year***	***mean***	***variance***	***SE***	***CV***	***Pop Var***	***Pop***	***Var(pop)***	***Low CI***	***High CI***	***3-yrMean***	***3-yrVar***	***3-yr SE***	***3-yrCV***
Males	1980	12.859	9.87E+00	3.14E+00	24.4	4.05E+03	8.33E+07	4.14E+14	6.7	19.017				
Males	1981	18.249	1.61E+01	4.01E+00	22	1.37E+04	1.18E+08	6.71E+14	10.391	26.108				
Males	1982	23.705	4.25E+01	6.52E+00	27.5	1.67E+04	1.54E+08	1.78E+15	10.93	36.48	18.271	2.28E+01	4.775971	26.13963
Males	1983	23.622	1.81E+01	4.26E+00	18	7.94E+03	1.53E+08	7.60E+14	15.279	31.965	21.85867	2.56E+01	5.055525	23.12824
Males	1984	13.338	2.34E+01	4.84E+00	36.3	8.51E+03	8.64E+07	9.83E+14	3.85	22.826	20.22167	2.80E+01	5.292542	26.17263
Males	1985	80.175	7.34E+02	2.71E+01	33.8	1.82E+05	5.19E+08	3.08E+16	27.073	133.277	39.045	2.59E+02	16.07877	41.18011
Males	1986	9.457	7.33E+00	2.71E+00	28.6	3.52E+03	6.13E+07	3.08E+14	4.151	14.764	34.32333	2.55E+02	15.96656	46.5181
Males	1987	39.298	2.19E+02	1.48E+01	37.7	5.66E+04	2.52E+08	9.04E+15	10.269	68.326	42.97667	3.20E+02	17.89516	41.63925
Males	1988	29.467	1.28E+02	1.13E+01	38.4	7.16E+04	1.89E+08	5.25E+15	7.302	51.632	26.074	1.18E+02	10.87153	41.6949
Males	1989	29.574	7.58E+01	8.71E+00	29.4	2.05E+04	1.87E+08	3.04E+15	12.505	46.642	32.77967	1.41E+02	11.87541	36.22797
Males	1990	47.791	6.32E+02	2.51E+01	52.6	2.38E+05	3.06E+08	2.59E+16	-1.484	97.066	35.61067	2.79E+02	16.69088	46.87044
Males	1991	32.294	8.47E+01	9.21E+00	28.5	2.70E+04	2.07E+08	3.49E+15	14.251	50.337	36.553	2.64E+02	16.25431	44.46779
Males	1992	38.223	6.45E+01	8.03E+00	21	2.76E+04	2.39E+08	2.52E+15	22.487	53.958	39.436	2.60E+02	16.1372	40.91998
Males	1993	32.57	2.23E+02	1.49E+01	45.9	6.04E+04	2.08E+08	9.13E+15	3.297	61.843	34.36233	1.24E+02	11.13954	32.41788
Males	1994	53.391	7.91E+01	8.89E+00	16.7	4.23E+04	3.42E+08	3.24E+15	35.961	70.821	41.39467	1.22E+02	11.05459	26.70535
Males	1995	25.754	2.46E+01	4.96E+00	19.3	5.68E+03	1.65E+08	1.02E+15	16.029	35.48	37.23833	1.09E+02	10.43676	28.02693
Males	1996	52.633	1.94E+02	1.39E+01	26.4	6.09E+04	3.38E+08	7.98E+15	25.362	79.904	43.926	9.91E+01	9.954865	22.66281
Males	1997	29.594	2.89E+01	5.37E+00	18.2	6.69E+03	1.89E+08	1.18E+15	19.065	40.123	35.99367	8.24E+01	9.075057	25.21293
Males	1998	32.353	6.71E+01	8.19E+00	25.3	2.13E+04	2.08E+08	2.76E+15	16.293	48.413	38.19333	9.65E+01	9.824951	25.72426
Males	1999	35.452	4.09E+01	6.40E+00	18	1.38E+04	2.23E+08	1.61E+15	22.915	47.989	32.46633	4.56E+01	6.75559	20.80799
Males	2000	22.24	3.49E+01	5.91E+00	26.6	7.24E+03	1.43E+08	1.44E+15	10.657	33.824	30.015	4.77E+01	6.903767	23.00106
Males	2001	20.345	3.11E+01	5.57E+00	27.4	1.02E+04	1.31E+08	1.28E+15	9.418	31.272	26.01233	3.56E+01	5.970036	22.95079
Males	2002	32.174	3.76E+01	6.13E+00	19	1.83E+04	2.07E+08	1.55E+15	20.162	44.186	24.91967	3.45E+01	5.875656	23.57839
Males	2003	32.45	2.51E+01	5.01E+00	15.4	7.09E+04	2.08E+08	1.03E+15	22.637	42.262	28.323	3.12E+01	5.588798	19.73237

Table B7.2 Summary of input values for swept area scenarios.

(These estimates of wing spread, door spread, and tow length are provisional and subject to change per further analysis)

(The data are incorporated as part of this assessment complements of Henry Milliken, NEFSC)

	door spread(m)	**wing spread (m)**	**mid range (m)**
ave Albatross	22.98	11.07	17.02
sd Albatross	1.34	0.64	0.99
CV Albatross	0.06	0.06	0.06

Distance per tow	***nautical mile***
mean	1.874
std dev	0.112
CV	0.060

Conversion Factor	1m =	0.000539957	nautical miles

Estimated area swept per tow

Area per tow (nm^2)	***Max (based on Door)***	***Min(based on wing spread)***	***Midrange***	***Max/min***
mean	0.02325	0.01120	0.01722	2.076455081
std dev= (CV*mean)	0.00140	0.00067	0.00103	
CV(fixed at 0.06 per above)	0.06	0.06	0.06	

Table B7.3. Summary of stochastic biomass estimates (mt) based on minimum footprint assumption

	Total Exploitable Biomass				Exploitable Biomass Females				Exploitable Biomass Males			
year	mean	0.25	0.5	0.75	mean	0.25	0.5	0.75	mean	0.25	0.5	0.75
1990	158675	128000	157000	187000	142228	116000	141000	166000	15947	10000	15000	20000
1991	154569	123000	153000	183000	122742	100000	121000	143000	31327	22000	30000	39000
1992	151735	127000	150000	174000	116977	99000	116000	132000	34259	26000	33000	40000
1993	126194	107000	125000	143000	110008	94000	109000	124000	15686	12000	15000	17000
1994	92274	79000	91000	103000	80084	69000	79000	89000	11690	8000	11000	13000
1995	100649	80000	99000	119000	88312	70000	87000	105000	11837	9000	11000	13000
1996	234061	190000	232000	276000	104655	82000	103000	125000	128906	107000	128000	149000
1997	215815	173000	214000	256000	80225	60000	79000	98000	135090	111000	134000	156000
1998	143733	124000	142000	161000	64280	56000	63000	71000	78954	67000	78000	89000
1999	134714	113000	133000	154000	61030	51000	60000	69000	73184	61000	72000	83000
2000	131675	110000	130000	151000	64707	53000	64000	74000	66468	55000	65000	75000
2001	143773	118000	142000	167000	77513	62000	76000	90000	65761	54000	65000	75000
2002	139833	120000	138000	158000	59769	50000	59000	67000	79564	68000	78000	89000

148285

	Total biomass (both sexes)				SSB (females >80 cm)			
Year	mean	0.25	0.5	0.75	mean	0.25	0.5	0.75
1990	582274	453000	579000	708000	234229	192000	232000	274000
1991	664850	524000	662000	801000	269624	221000	268000	315000
1992	553731	459000	551000	644000	220002	188000	218000	250000
1993	544415	460000	542000	625000	186132	159000	185000	210000
1994	460932	390000	459000	529000	133264	115000	132000	149000
1995	519920	428000	517000	608000	120664	96000	119000	143000
1996	520782	421000	518000	617000	114091	89000	113000	137000
1997	489233	391000	487000	584000	91458	69000	90000	112000
1998	406287	353000	404000	456000	51821	45000	51000	57000
1999	358185	303000	356000	410000	52562	44000	51000	59000
2000	343602	288000	342000	396000	61552	50000	60000	71000
2001	337686	280000	336000	392000	64844	52000	64000	76000
2002	371200	319000	369000	420000	58376	49000	57000	66000

min	337686	51821
max	664850	269624
average	473315	127586

Table B7.4. Summary of stochastic biomass estimates (mt) based on maximum footprint assumption

	Total Exploitable Biomass				Exploitable Biomass Females				Exploitable Biomass Males			
year	mean	0.25	0.5	0.75	mean	0.25	0.5	0.75	mean	0.25	0.5	0.75
1990	76157	61000	75000	89000	68236	55000	67000	79000	7422	4000	6000	9000
1991	74180	59000	73000	87000	58852	47000	58000	68000	14828	10000	14000	18000
1992	72815	60000	72000	83000	56076	47000	55000	63000	16239	12000	15000	19000
1993	60514	51000	59000	68000	52719	44000	52000	59000	7295	5000	6000	8000
1994	44179	37000	43000	49000	38309	32000	37000	42000	5370	3000	4000	5000
1995	48212	38000	47000	56000	42271	33000	41000	50000	5441	4000	4000	5000
1996	112462	91000	111000	132000	50142	39000	49000	60000	61821	51000	61000	71000
1997	103675	83000	102000	122000	38376	28000	37000	46000	64799	53000	64000	75000
1998	68961	59000	68000	77000	30697	26000	30000	33000	37764	31000	37000	42000
1999	64618	54000	63000	73000	29133	24000	28000	33000	34985	29000	34000	39000
2000	63154	52000	62000	72000	30903	25000	30000	35000	31751	26000	31000	36000
2001	68981	56000	68000	80000	37070	29000	36000	43000	31411	25000	30000	35000
2002	67083	57000	66000	75000	28525	23000	27000	32000	38058	32000	37000	42000

	Total biomass (both sexes)				SSB (females >80 cm)			
Year	mean	0.25	0.5	0.75	mean	0.25	0.5	0.75
1990	280158	217000	278000	340000	112543	92000	111000	131000
1991	319926	252000	318000	385000	129589	106000	128000	151000
1992	266412	220000	265000	309000	105692	90000	104000	119000
1993	261926	221000	260000	300000	89380	76000	88000	100000
1994	221721	187000	220000	254000	63920	55000	63000	71000
1995	250129	206000	248000	292000	57851	45000	57000	68000
1996	250544	202000	249000	296000	54686	42000	54000	65000
1997	235351	187000	234000	280000	43786	32000	43000	53000
1998	195405	169000	194000	219000	24697	21000	24000	27000
1999	172239	145000	171000	197000	25054	20000	24000	28000
2000	165216	138000	164000	190000	29383	23000	28000	33000
2001	162367	134000	161000	188000	30969	24000	30000	36000
2002	178507	153000	177000	201000	27854	23000	27000	31000

Table B7.5. Summary of Stochastic F estimates based on assumed minimum footprint

	F1: F on Exploitable Biomass				F2: Discard F on Total Biomass				Biomass Weighted F (F1,F2)			
year	average	0.25	0.5	0.75	average	0.25	0.5	0.75	average	0.25	0.5	0.75
1990	0.108	0.084	0.100	0.123	0.091	0.055	0.080	0.113	0.122	0.080	0.108	0.146
1991	0.094	0.071	0.086	0.106	0.080	0.056	0.072	0.095	0.103	0.073	0.092	0.120
1992	0.122	0.099	0.115	0.136	0.041	0.031	0.037	0.046	0.075	0.059	0.069	0.084
1993	0.181	0.151	0.173	0.201	0.028	0.019	0.026	0.033	0.070	0.056	0.066	0.079
1994	0.230	0.195	0.221	0.255	0.022	0.017	0.020	0.025	0.069	0.056	0.065	0.077
1995	0.253	0.195	0.233	0.288	0.023	0.016	0.020	0.025	0.071	0.056	0.066	0.080
1996	0.126	0.098	0.117	0.143	0.030	0.022	0.026	0.033	0.087	0.067	0.080	0.098
1997	0.094	0.072	0.086	0.106	0.015	0.007	0.013	0.020	0.057	0.042	0.052	0.066
1998	0.155	0.132	0.149	0.171	0.012	0.009	0.011	0.013	0.067	0.057	0.064	0.074
1999	0.134	0.110	0.127	0.150	0.012	0.009	0.011	0.013	0.063	0.051	0.059	0.070
2000	0.095	0.077	0.089	0.106	0.013	0.009	0.011	0.014	0.049	0.039	0.046	0.055
2001	0.044	0.034	0.041	0.049	0.028	0.021	0.026	0.032	0.047	0.037	0.043	0.053
2002	0.041	0.034	0.038	0.045	0.019	0.015	0.017	0.020	0.034	0.028	0.032	0.038

	F3: (Fem .Landings)/Female Expl. Biomass				F4: (Male Landings)/Male Expl. Biomass			
year	average	0.25	0.5	0.75	average	0.25	0.5	0.75
1990	0.119	0.094	0.111	0.135	0.004	0.001	0.002	0.004
1991	0.115	0.091	0.107	0.130	0.003	0.001	0.001	0.002
1992	0.156	0.130	0.149	0.174	0.000	#N/A	#N/A	0.000
1993	0.205	0.173	0.197	0.228	0.011	0.008	0.009	0.011
1994	0.260	0.224	0.252	0.287	0.023	0.017	0.020	0.025
1995	0.288	0.220	0.264	0.329	0.011	0.008	0.010	0.012
1996	0.241	0.180	0.218	0.276	0.037	0.029	0.034	0.041
1997	0.167	0.119	0.147	0.191	0.053	0.042	0.049	0.059
1998	0.324	0.282	0.316	0.357	0.015	0.012	0.014	0.016
1999	0.244	0.201	0.232	0.273	0.042	0.034	0.039	0.046
2000	0.185	0.149	0.174	0.208	0.008	0.005	0.006	0.008
2001	0.080	0.062	0.073	0.090	0.003	0.001	0.002	0.002
2002	0.094	0.078	0.090	0.105	0.001	0.000	0.000	0.000

average	0.191

Table B7.6. Summary of Stochastic F estimates based on assumed maximum footprint

	F1: F on Exploitable Biomass				F2: Discard F on Total Biomass				Biomass Weighted F (F1,F2)			
year	average	0.25	0.5	0.75	average	0.25	0.5	0.75	average	0.25	0.5	0.75
1990	0.225	0.175	0.208	0.256	0.189	0.116	0.169	0.237	0.251	0.168	0.226	0.306
1991	0.195	0.15	0.179	0.222	0.167	0.117	0.151	0.198	0.214	0.154	0.193	0.25
1992	0.253	0.208	0.241	0.285	0.085	0.065	0.079	0.098	0.155	0.123	0.146	0.177
1993	0.376	0.316	0.361	0.42	0.058	0.042	0.055	0.07	0.147	0.118	0.139	0.166
1994	0.471	0.407	0.461	0.531	0.047	0.036	0.044	0.054	0.144	0.118	0.137	0.162
1995	0.487	0.407	0.486	0.598	0.047	0.036	0.044	0.054	0.148	0.117	0.138	0.168
1996	0.263	0.206	0.244	0.299	0.062	0.047	0.056	0.07	0.181	0.14	0.167	0.206
1997	0.195	0.15	0.18	0.222	0.033	0.017	0.029	0.042	0.119	0.088	0.109	0.138
1998	0.322	0.276	0.312	0.357	0.026	0.02	0.024	0.029	0.140	0.119	0.135	0.155
1999	0.278	0.23	0.265	0.312	0.026	0.019	0.023	0.029	0.131	0.107	0.124	0.146
2000	0.197	0.161	0.187	0.221	0.027	0.021	0.025	0.03	0.103	0.083	0.097	0.115
2001	0.092	0.073	0.086	0.103	0.059	0.045	0.055	0.067	0.098	0.078	0.092	0.111
2002	0.085	0.072	0.082	0.094	0.040	0.032	0.037	0.044	0.072	0.06	0.069	0.08

	F3: (Fem .Landings)/Female Expl. Biomass				F4: (Male Landings)/Male Expl. Biomass			
year	average	0.25	0.5	0.75	average	0.25	0.5	0.75
1990	0.248	0.197	0.232	0.281	0.009	0.004	0.006	0.009
1991	0.240	0.191	0.225	0.272	0.006	0.003	0.004	0.006
1992	0.324	0.272	0.312	0.362	0.002	0	0	0.001
1993	0.424	0.361	0.411	0.475	0.023	0.017	0.021	0.025
1994	0.521	0.466	0.525	0.598	0.048	0.037	0.044	0.054
1995	0.525	0.459	0.55	0.598	0.024	0.019	0.022	0.026
1996	0.463	0.375	0.454	0.574	0.078	0.063	0.073	0.088
1997	0.338	0.248	0.307	0.399	0.111	0.089	0.104	0.125
1998	0.585	0.588	0.598	0.598	0.033	0.027	0.03	0.035
1999	0.489	0.42	0.484	0.569	0.088	0.072	0.083	0.098
2000	0.382	0.311	0.363	0.434	0.017	0.013	0.015	0.018
2001	0.166	0.13	0.154	0.188	0.007	0.004	0.005	0.007
2002	0.197	0.164	0.188	0.219	0.002	0.001	0.001	0.002

Table B8.1 Summary of input data for stock recruitment analyses of spiny dogfish.

	Survey Data				Survey Data Scaled to Nomimal Footprint (0.01 nm^2)	
	Raw Data		2-Pt Moving Average		2 -yr moving average	
Year	*Recruits (Num/Tow)*	*SSB (kg/tow)*	*Recruits (Num/tow)*	*SSB (kg/tow)*	*Recruits (000's)*	*SSB (mt)*
1968	2.881	5.37	.	.	.	.
1969	1.248	3.55	2.065	4.46	13,374	28,884
1970	8.250	4.76	4.749	4.16	30,760	26,916
1971	5.905	13.47	7.077	9.11	45,841	59,034
1972	3.909	16.43	4.907	14.95	31,785	96,814
1973	5.183	23.18	4.546	19.81	29,445	128,278
1974	5.948	28.78	5.565	25.98	36,046	168,294
1975	7.851	13.63	6.899	21.21	44,686	137,366
1976	2.718	12.49	5.285	13.06	34,229	84,616
1977	1.110	10.03	1.914	11.26	12,399	72,952
1978	2.759	11.34	1.934	10.69	12,530	69,205
1979	3.883	6.79	3.321	9.06	21,510	58,688
1980	1.356	16.16	2.620	11.47	18,069	78,154
1981	8.853	41.25	5.104	28.71	35,110	189,423
1982	2.459	70.09	5.656	55.67	37,580	360,246
1983	12.990	12.00	7.725	41.05	50,033	265,861
1984	0.744	17.84	6.867	14.92	44,478	96,647
1985	19.799	48.95	10.272	33.40	66,530	216,304
1986	3.982	29.53	11.891	39.24	77,017	254,141
1987	12.942	34.13	8.462	31.83	54,443	205,196
1988	3.671	67.57	8.306	50.85	53,313	326,141
1989	5.482	25.59	4.576	46.58	29,128	297,611
1990	3.841	62.51	4.661	44.05	29,661	281,184
1991	4.548	34.32	4.195	48.42	26,899	310,322
1992	3.663	44.41	4.105	39.36	26,170	250,438
1993	3.060	36.68	3.362	40.54	21,357	257,578
1994	15.840	16.45	9.450	26.56	60,501	169,975
1995	1.151	15.95	8.496	16.20	54,408	103,872
1996	5.276	30.60	3.214	23.28	20,634	149,461
1997	0.281	13.09	2.778	21.85	17,835	140,080
1998	0.454	4.16	0.367	8.63	2,353	55,188
1999	0.143	9.98	0.299	7.07	1,907	44,692
2000	0.479	13.36	0.311	11.67	1,990	74,239
2001	0.208	8.83	0.344	11.10	2,207	71,235
2002	0.297	11.71	0.253	10.27	1,622	65,921
2003	0.825	10.05	0.561	10.88	3,602	69,860

Table B8.2. Summary of parameter estimates for Ricker stock-recruitment model

						95% Confidence Interval	
Years Included	*Data*	*Units*	*Parameter*	*Estimate*	*Asymptotic SE*	*Lower Bound*	*Upper Bound*
1968-96	Swept Area 2-yr avg.		A	0.541578	0.109155	0.31761	0.765546
			B	-0.000005	0.000001	-0.000007	-0.000003
		thousands	RMAX (000')	42,839	3,517	35,622	50,055
		mt	SSBMAX (mt)	215,014	43,749	125,249	304,780
			R-sqr	0.172			
			MSE	7.925 E+9			
	Raw (2-yr avg.)		A	0.543445	0.108853	0.320097	0.766793
			B	-0.030141	0.006055	-0.042565	-0.017717
		num/tow	RMAX	6.632914	0.542621	5.519549	7.74628
		kg/tow	SSBMAX	33.177455	6.665081	19.501838	46.853071
			R-sqr	0.178			
			MSE	190.97			
	Raw		A	0.521389	0.16949	0.174204	0.868574
			B	-0.027862	0.009425	-0.047169	-0.008555
		num/tow	RMAX	6.884334	1.118478	4.593236	9.175431
		kg/tow	SSBMAX	35.891764	12.141952	11.020103	60.763425
			R-sqr	0.055			
			MSE	625.76			
1968-2003	Swept Area 2-yr avg.		A	0.391858	0.085433	0.218043	0.565672
			B	-0.000003	0.000001	-0.000005	-0.000001
		thousands	RMAX	42,388	5,296	31,614	53,162
		mt	SSBMAX	294,040	84,867	121,377	466,702
			R-sqr	3.28E-01			
			MSE	1.349 E+10			
	Raw (2-yr avg.)		A	0.392663	0.085433	0.218849	0.566477
			B	-0.022092	0.006306	-0.034922	-0.009263
		num/tow	RMAX	6.538571	0.806394	4.897951	8.179192
		kg/tow	SSBMAX	45.264321	12.920044	18.978295	71.550348
			R-sqr	0.327			
			MSE	323.48			
	Raw		A	0.415334	0.128512	0.154166	0.676502
			B	-0.023003	0.008578	-0.040436	-0.00557
		num/tow	RMAX	6.642318	1.218106	4.16683	9.117807
		kg/tow	SSBMAX	43.472882	16.211689	10.526764	76.418999
			R-sqr	0.125			
			MSE	750.306			

Table B9.1. Summary of Projection model comparisons, assuming the minimum footprint

		Average over Decade								
Scenario	decade	Average of F	SSB (mt)	Probability of exceeding Target Biomass	Probability of exceeding Threshold biomass	Yield (mt)	Exploitable Biomass of Females (mt)	Exploitable Biomass of Males (mt)	Total Biomass of Females (mt)	Total Biomass (mt)
Rebuild_F	2003-2012	0.03	122,102	0.0426	0.8042	3,873		24,684	167,868	414,500
	2013-2022	0.03	148,872	0.2118	0.9452	4,387	137,585	17,292	233,454	424,223
	2023-2033	0.03	214,573	0.7416	1	6,109	199,706	16,079	326,661	537,313
SQ_F	2003-2012	0.094	98,163	0	0.5724	9,851	89,310	23,929	141,334	380,065
	2013-2022	0.094	89,465	0	0.4576	8,367	81,282	15,077	149,051	304,816
	2023-2033	0.094	97,861	0	0.6394	8,773	90,040	11,228	158,649	291,472
ZeroF	2003-2012	0	136,277	0.1362	0.8436	-	125,382	25,051	183,419	434,000
	2013-2022	0	193,121	0.519	0.9946	-	179,924	18,497	294,071	505,973
	2023-2033	0	318,682	0.9852	1	-	298,226	19,343	471,684	739,736
alt_Q	2003-2012	0.0676	107,748	0.014	0.672	7,253	98,422	24,210	151,641	393,120
	2013-2022	0.0731	110,660	0.050	0.665	7,253	101,382	15,900	180,284	349,506
	2023-2033	0.0647	143,451	0.247	0.813	7,253	132,896	13,103	223,107	385,362
Base_Q	2003-2012	0.0446	116,003	0.031	0.746	5,116	106,211	24,478	160,846	405,147
	2013-2022	0.0417	134,540	0.146	0.844	5,116	124,020	16,755	213,223	395,519
	2023-2033	0.0306	194,681	0.557	0.971	5,116	181,175	15,036	295,750	489,638
NoComm	2003-2012	0.0276	122,984	0.055	0.793	3,336	112,806	24,687	168,624	415,178
	2013-2022	0.0235	154,741	0.264	0.935	3,336	143,252	17,401	241,092	433,903
	2023-2033	0.0174	225,626	0.757	0.975	3,337	210,594	16,292	342,758	559,116

Tabel B9.2. Comparison of projection model results at decadal waypoints.

		Average value in the year specified								
Scenario	Year	Average of F	SSB (mt)	Probability of exceeding Target Biomass	Probability of exceeding Threshold biomass	Yield (mt)	Exploitable Biomass of Females (mt)	Exploitable Biomass of Males (mt)	Total Biomass of Females (mt)	Total Biomass (mt)
Rebuild_F	2003	0.03	57,608	0	0	2,290	58,132	22,346	153,665	453,134
	2012	0.03	113,641	0	0.842	3,892	114,842	22,618	184,792	391,624
	2022	0.03	189,434	0.566	1	5,365	174,013	15,484	270,538	458,263
	2032	0.03	250,959	0.914	1	7,038	231,452	17,137	381,388	616,705
SQ_F	2003	0.094	57,608	0	0	7,070	58,132	22,346	153,665	453,134
	2012	0.094	71,971	0	0.1	8,212	73,562	21,136	133,638	322,779
	2022	0.094	103,262	0	0.726	9,207	93,922	12,378	152,158	289,445
	2032	0.094	104,320	0	0.742	9,106	94,460	10,627	165,940	297,200
ZeroF	2003	0	57,608	0	0	-	58,132	22,346	153,665	453,134
	2012	0	141,174	0.066	0.974	-	142,109	23,352	217,512	433,562
	2022	0	256,575	0.928	1	-	237,067	17,309	361,259	582,012
	2032	0	392,134	1	1	-	364,623	21,883	581,444	899,398
alt_Q	2003	0.0984	57,608	0.000	0.000	7,252	58,132	22,346	153,665	453,134
	2012	0.0723	90,693	0.000	0.496	7,253	92,056	21,773	155,487	351,691
	2022	0.0641	135,518	0.162	0.828	7,253	123,487	13,558	196,257	352,643
	2032	0.0624	161,989	0.384	0.838	7,254	148,540	13,130	250,646	421,805
Base_Q	2003	0.0689	57,608	0.000	0.000	5,116	58,132	22,346	153,665	453,134
	2012	0.0442	105,191	0.000	0.702	5,116	106,428	22,292	173,358	375,750
	2022	0.0342	170,904	0.402	0.964	5,116	156,599	14,761	244,281	420,105
	2032	0.0266	229,430	0.728	0.986	5,116	211,747	15,802	347,569	562,445
NoComm	2003	0.0447	57,608	0.000	0.000	3,336	58,132	22,346	153,665	453,134
	2012	0.0259	117,536	0.000	0.836	3,337	118,667	22,687	188,530	395,837
	2022	0.0186	200,603	0.634	1.000	3,335	184,461	15,688	284,733	476,376
	2032	0.0198	234,721	0.777	0.890	3,337	217,311	16,891	371,947	610,667

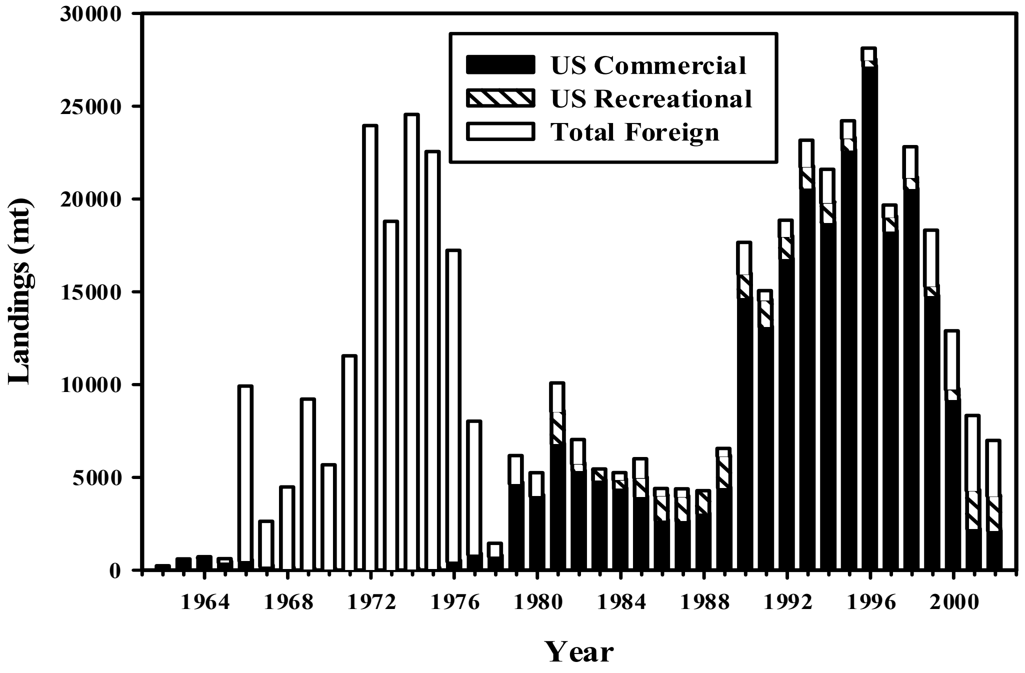


Figure B4.1. Commercial landings (metric tons) and recreational catch of spiny

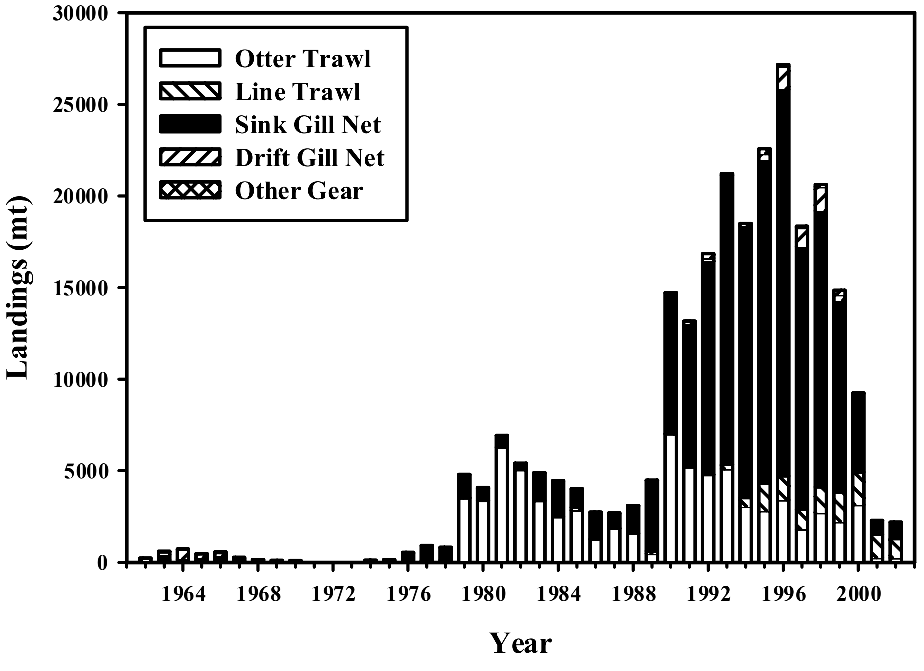


Figure B4.2. U. S. Landings of spiny dogfish from NAFO subareas 2-6 by gear type, 1962-2002.

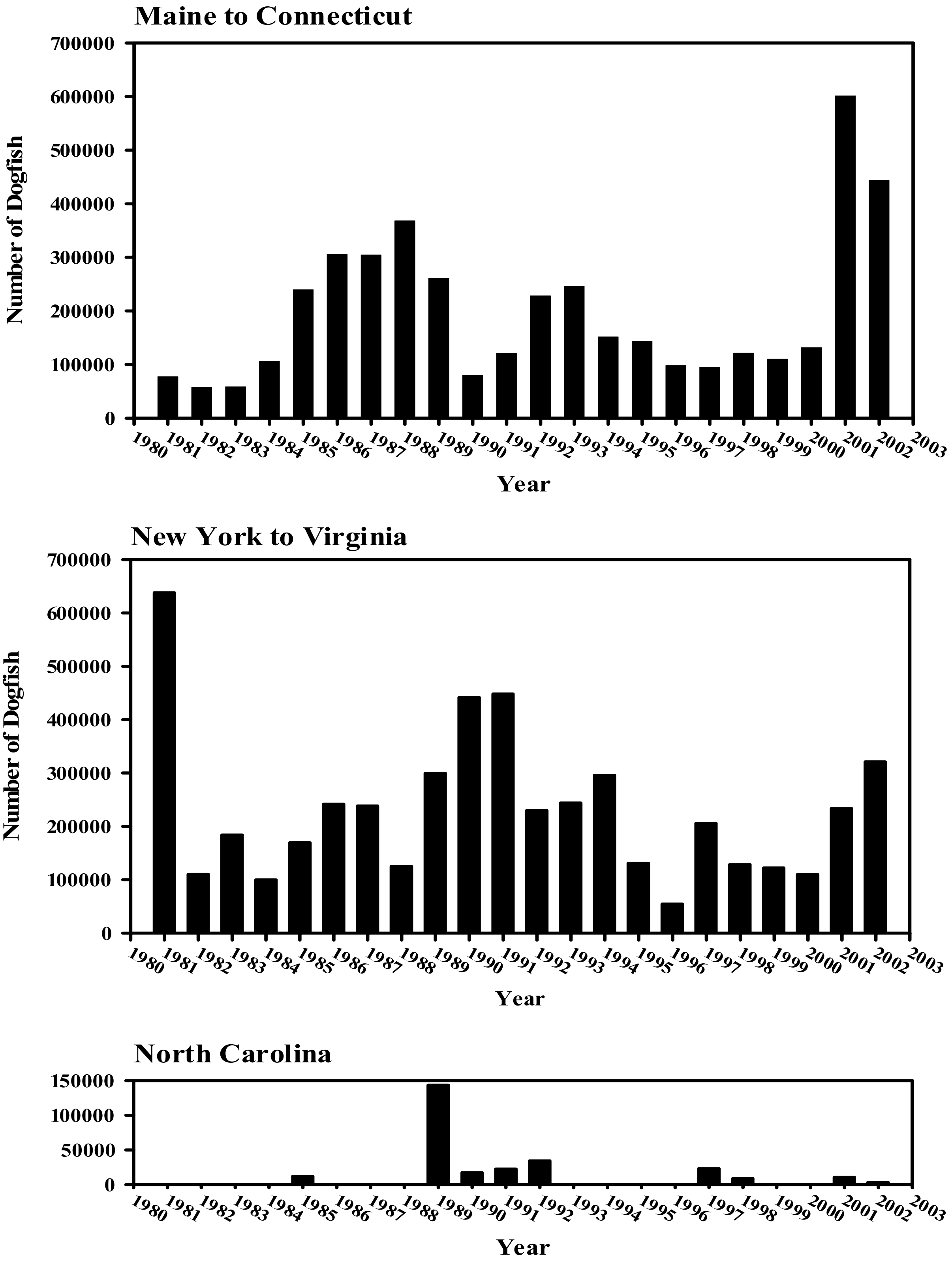
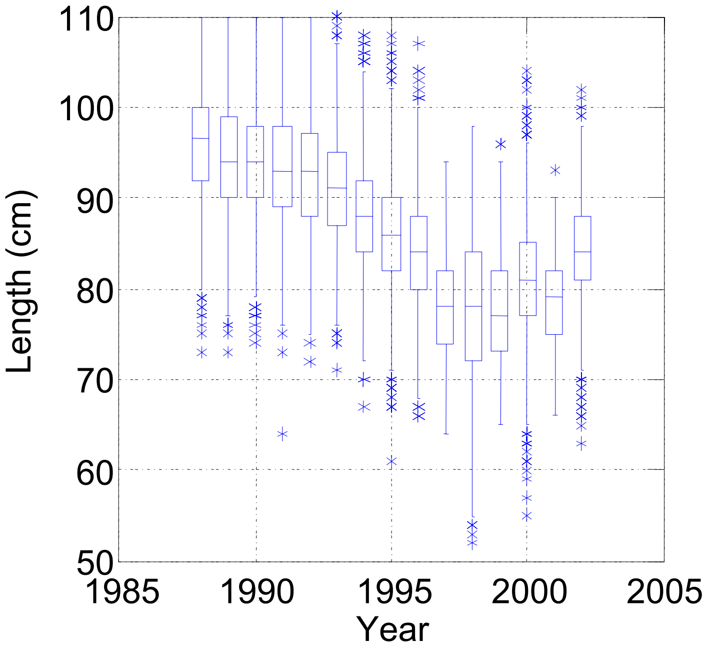
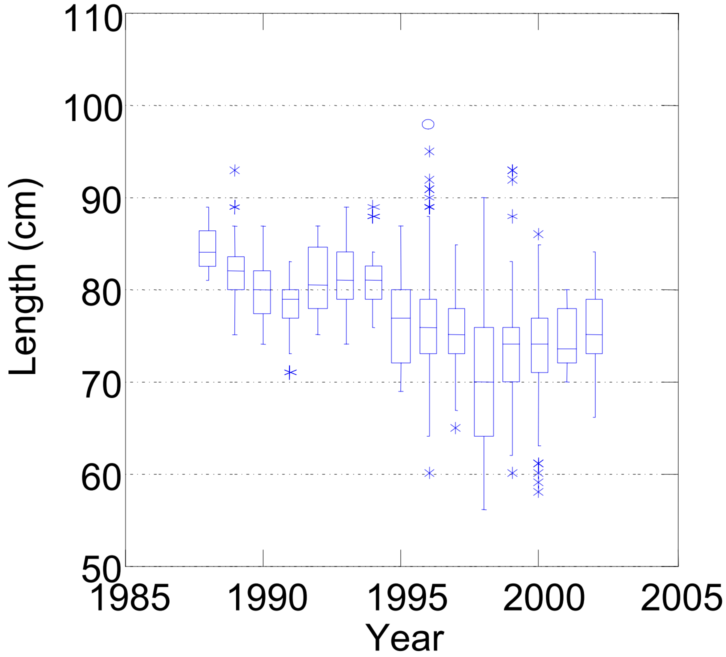


Table B4.3. Estimated total recreational catch of spiny dogfish (numbers of fish) by geographical area, 1981-2002.



Female Size Composition, Commercial Samples



Male Size Composition, Commercial Samples

Fig. B4.4 Box plots of length (cm) frequency of female and male dogfish in commercial fishery samples.

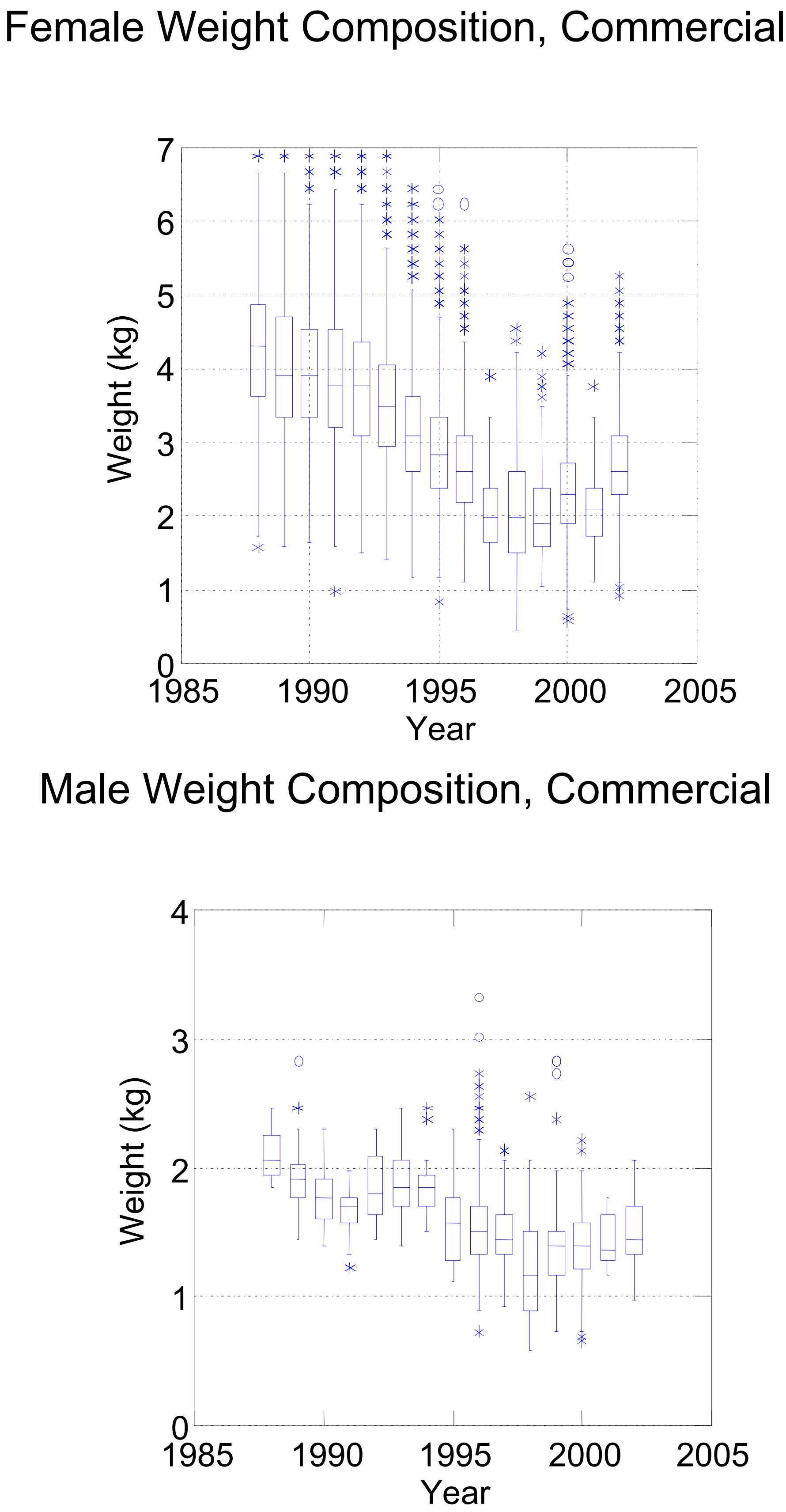
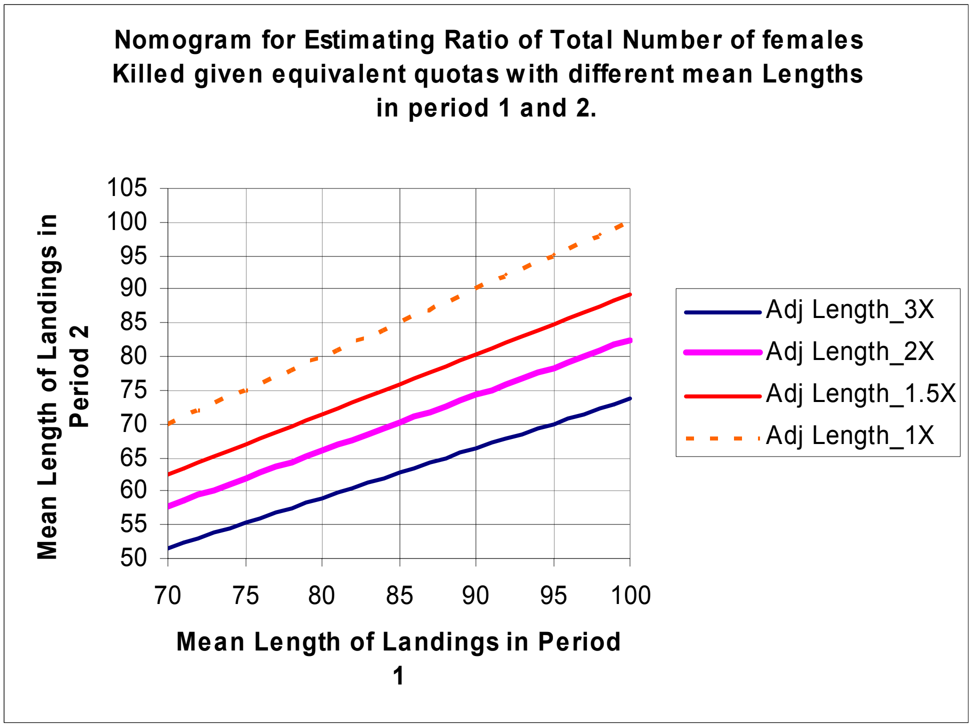


Fig. B4.5 Box plots of average weight (kg) of female and male dogfish in commercial fishery samples.



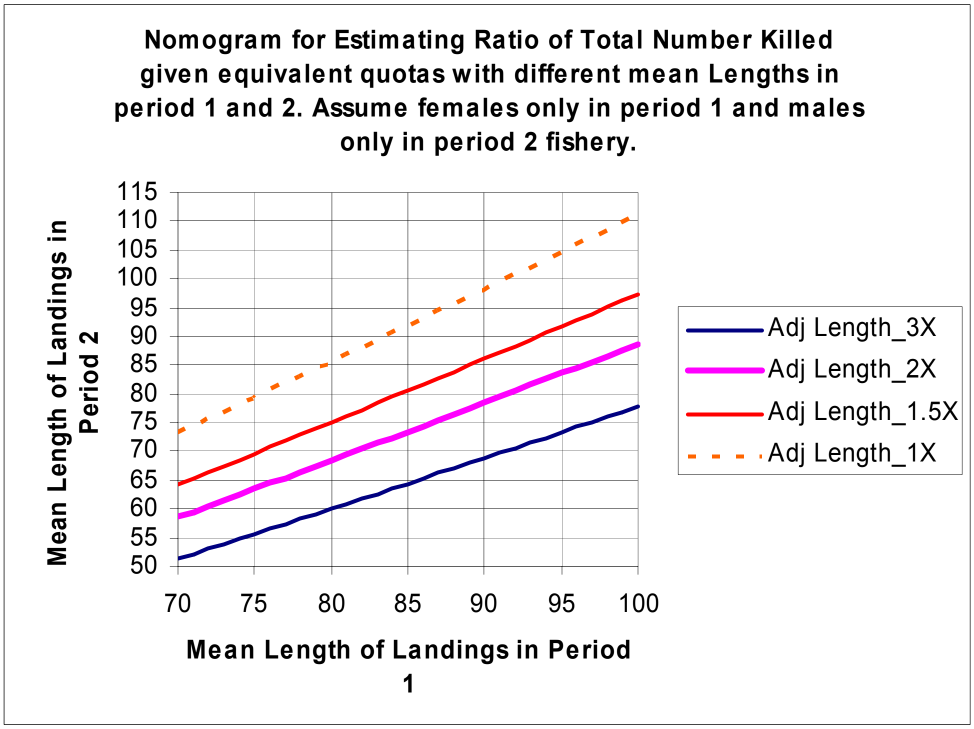
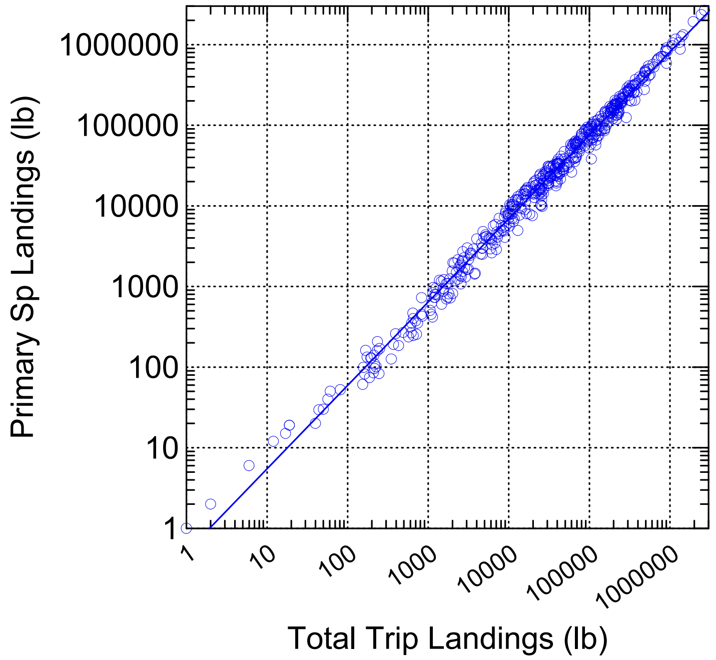


Fig. B4.6 Nomograms illustrating the increase in numbers of dogfish killed with alternative average sizes of dogfish in two landings periods.

All Gears and Species: Primary Sp.Group vs Tot Landings (lb)



All Gears and Species: Secondary Sp.Group vs Tot Landings (lb)

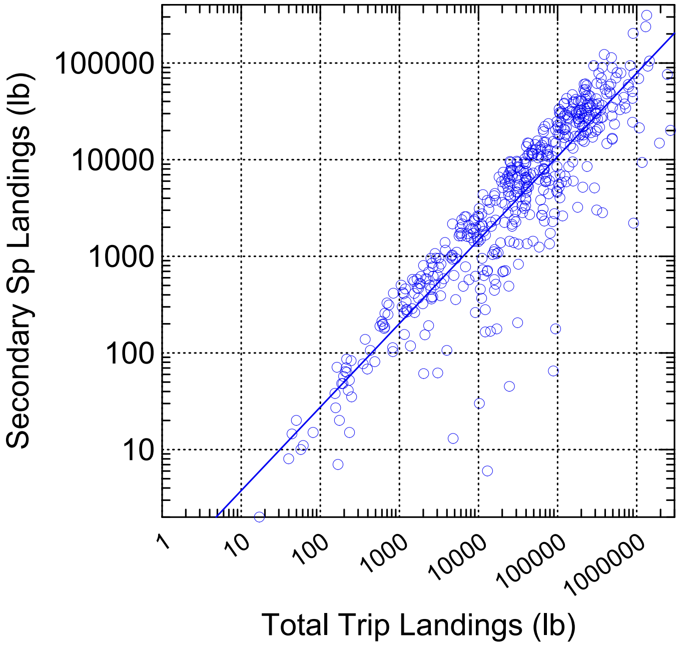
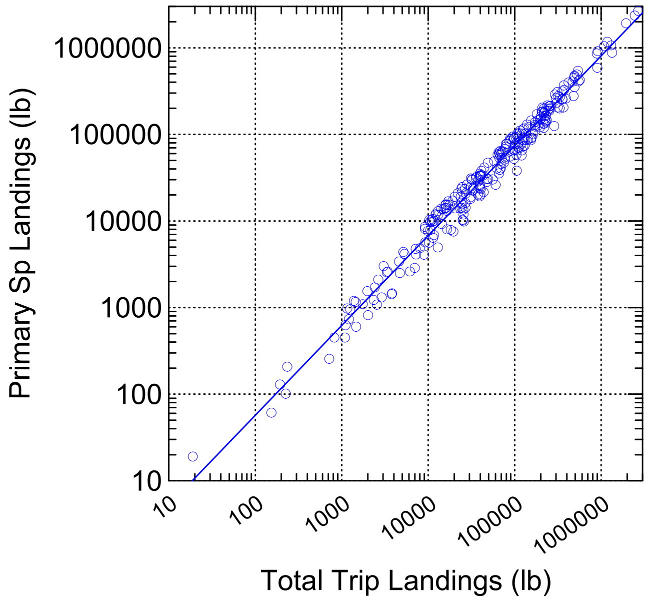
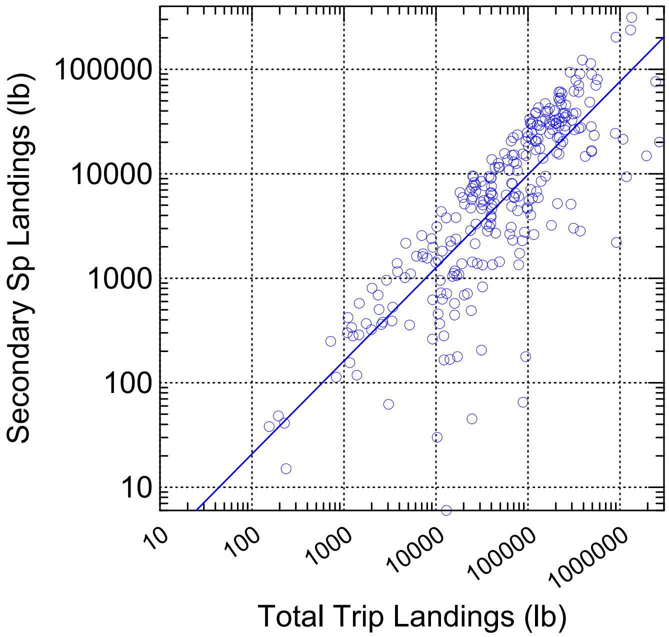


Fig B4.7. Relationship between total landings of all species and the landings of the primary species group (top) and secondary species group (bottom) on commercial vessel trips. At sea observers were onboard. All gears combined.



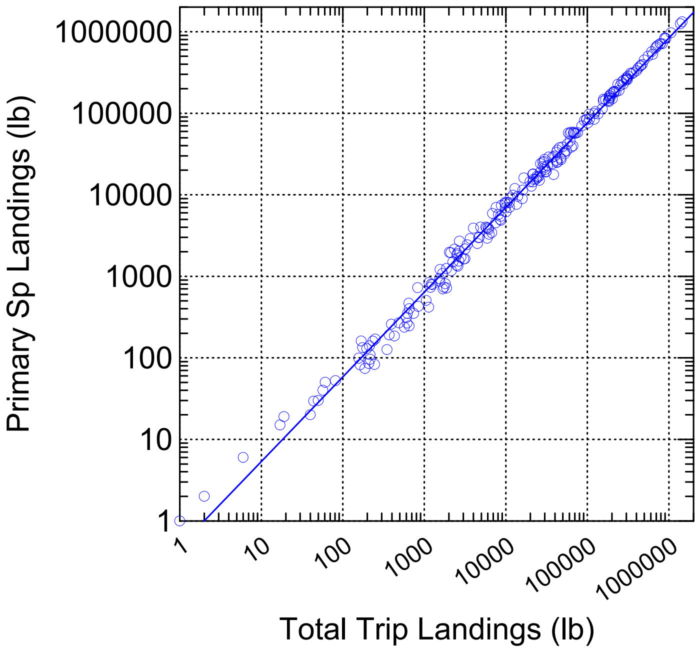
Trawls, All Species: Primary Sp.Group vs Tot Landings (lb)



Trawls, All Species: Secondary Sp.Group vs Tot Landings (lb)

Fig B4.8. Relationship between total landings of all species and the landings of the primary species group (top) and secondary species group (bottom) on commercial vessel trips using trawls. At sea observers were onboard

Gill Nets, All Species: Primary Sp.Group vs Tot Landings (lb)



Gill Nets, All Species: Secondary Sp.Group vs Tot Landings (lb)

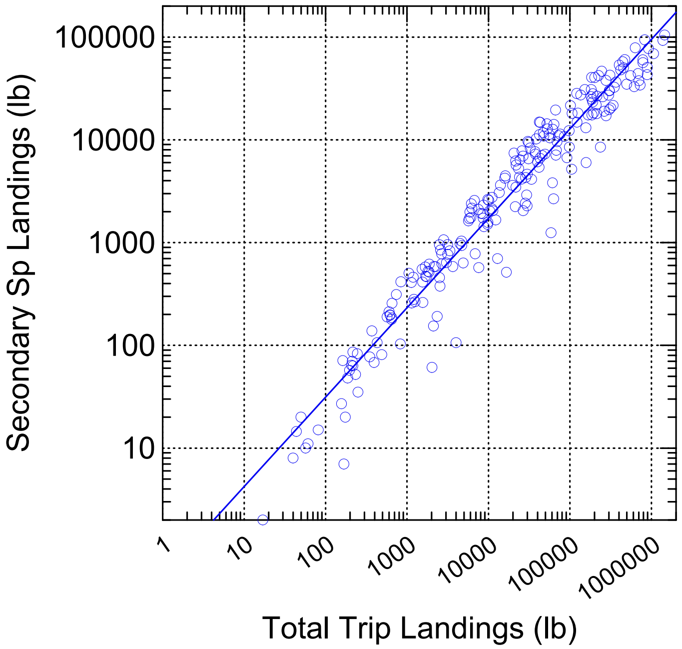


Fig B4.9. Relationship between total landings of all species and the landings of the primary species group (top) and secondary species group (bottom) on commercial vessel trips using gill nets. At sea observers were onboard

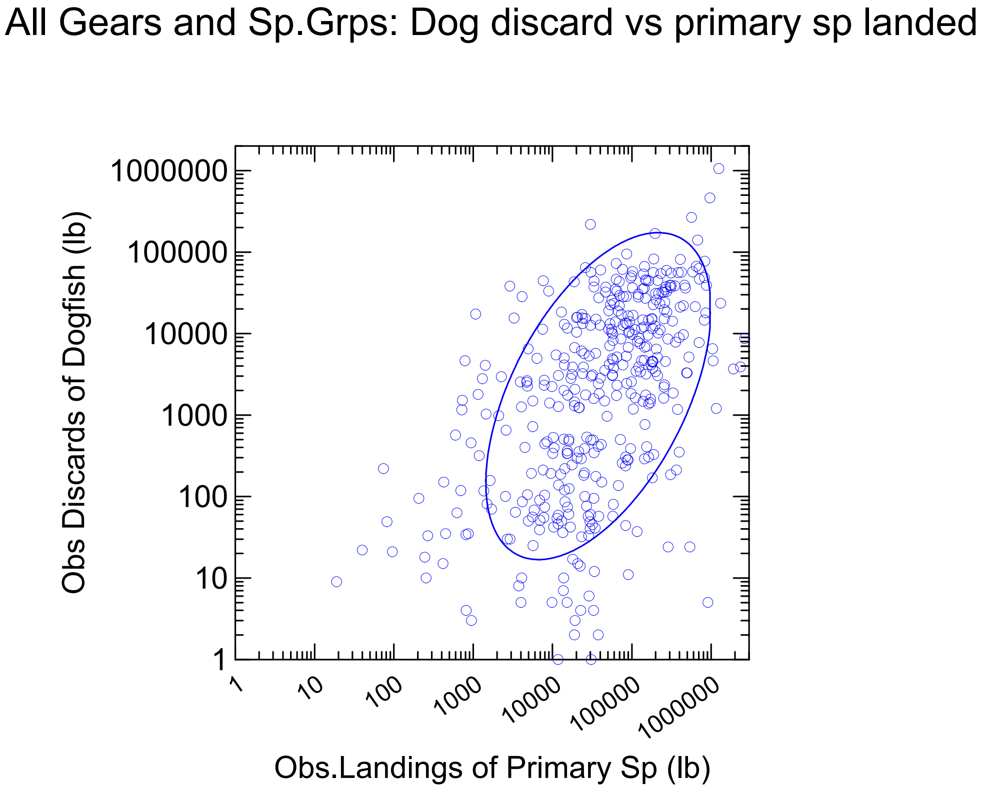
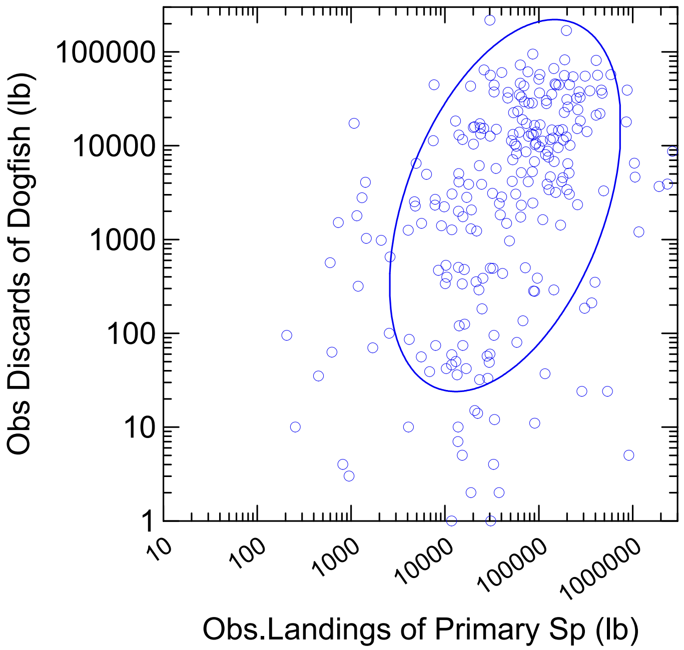


Fig. B4.10 Relationship between total dogfish discards and total landings of primary species group on commercial vessels with at sea observers on board. Each point represents an individual trip, 1989-2002. All gears and species groups combined. Confidence ellipse represents 0.68 probability level.

Trawl Gear and Sp.Grps: Dog discard vs primary sp landed



Gill Net Gear and Sp.Grps: Dog discard vs primary sp landed

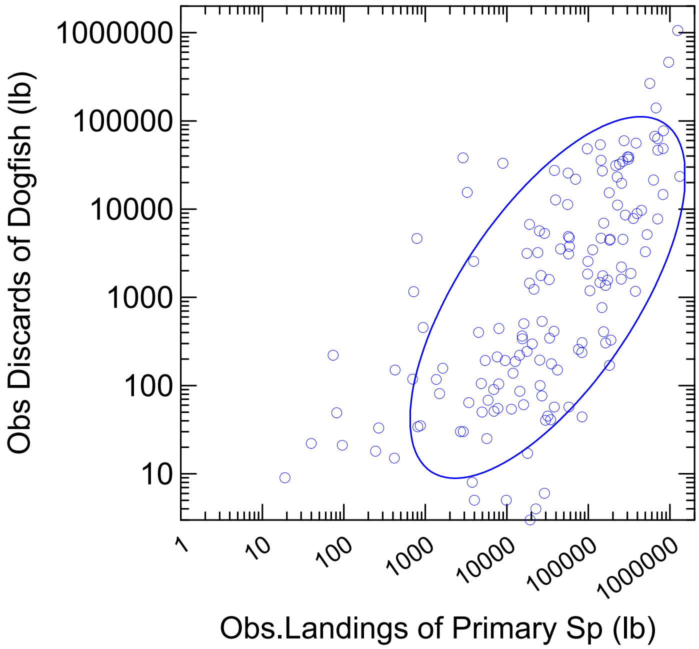
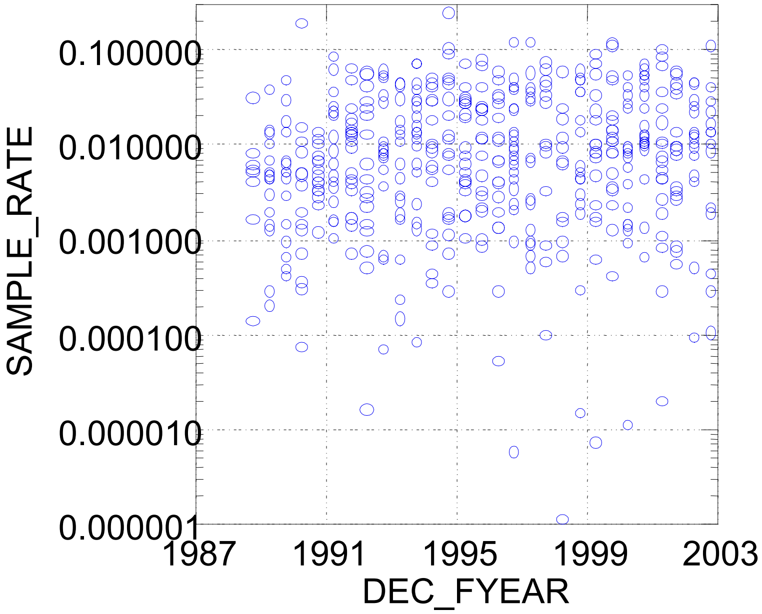


Fig. B4.11 Relationship between total dogfish discards and total landings of primary species group on commercial vessels with at sea observers on board. Each point represents an individual trip, 1989-2002. All species groups combined. Trawl gear (top panel); gill net gear (bottom panel) . Confidence ellipse represents 0.68 probability level.

All Gears and Sp.Grp: Sample Rate vs Fishing Period



All Gears and Sp Grp: Obs Landings(lb) vs Total Landings (mt)

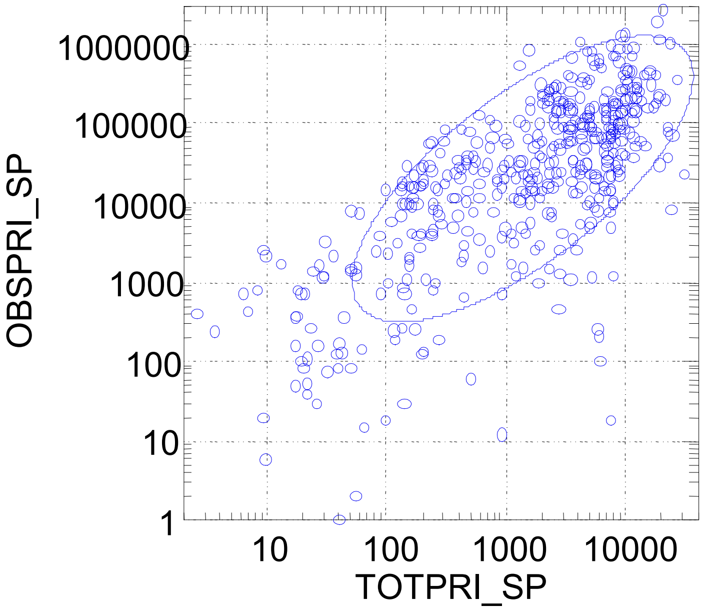
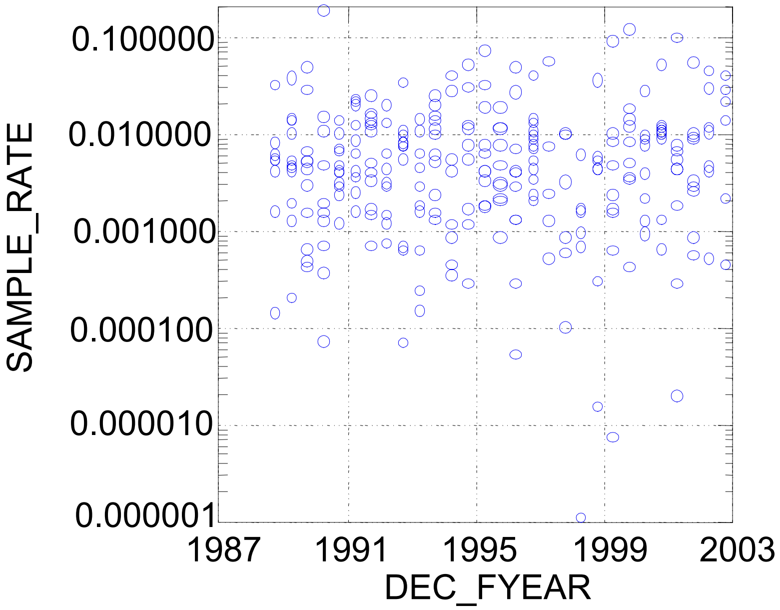


Fig. B4.12 Estimated sampling rate by month (denoted as decimal year) for each species group (top). Bottom panel illustrates relationship between total observed landings of primary species groups and gear groups and total landings those groups in commercial dealer database. Landings on X axis are in mt. Observed landings on Y axis are in pounds. Confidence ellipse represents 0.68 probability level.

Trawl Gear and Sp.Grp: Sample Rate vs Fishing Period



Trawl Gear and Sp Grp: Obs Landings(lb) vs Total Landings (mt)

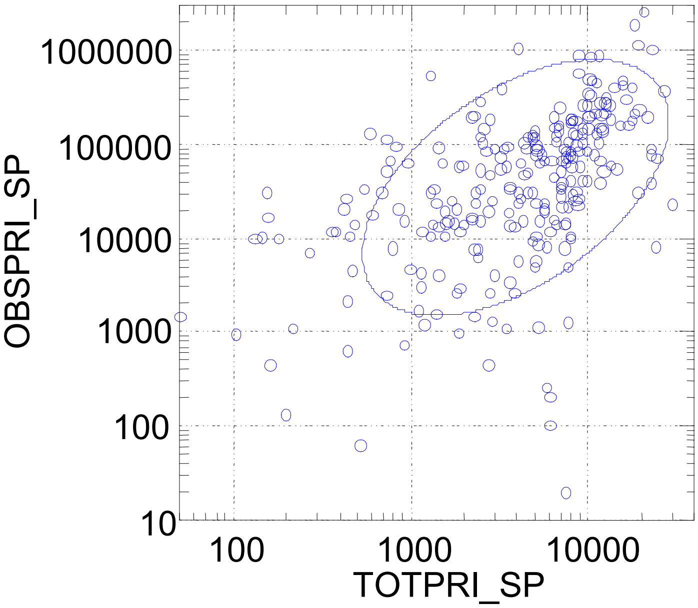


Fig. B4.13 Estimated sampling rate by month (denoted as decimal year) for each species group (top). Bottom panel illustrates relationship between total observed landings of primary species groups and total landings those groups in commercial dealer database. Landings on X axis are in mt. Observed landings on Y axis are in pounds. Only trawl gear. Confidence ellipse represents 0.68 probability level.

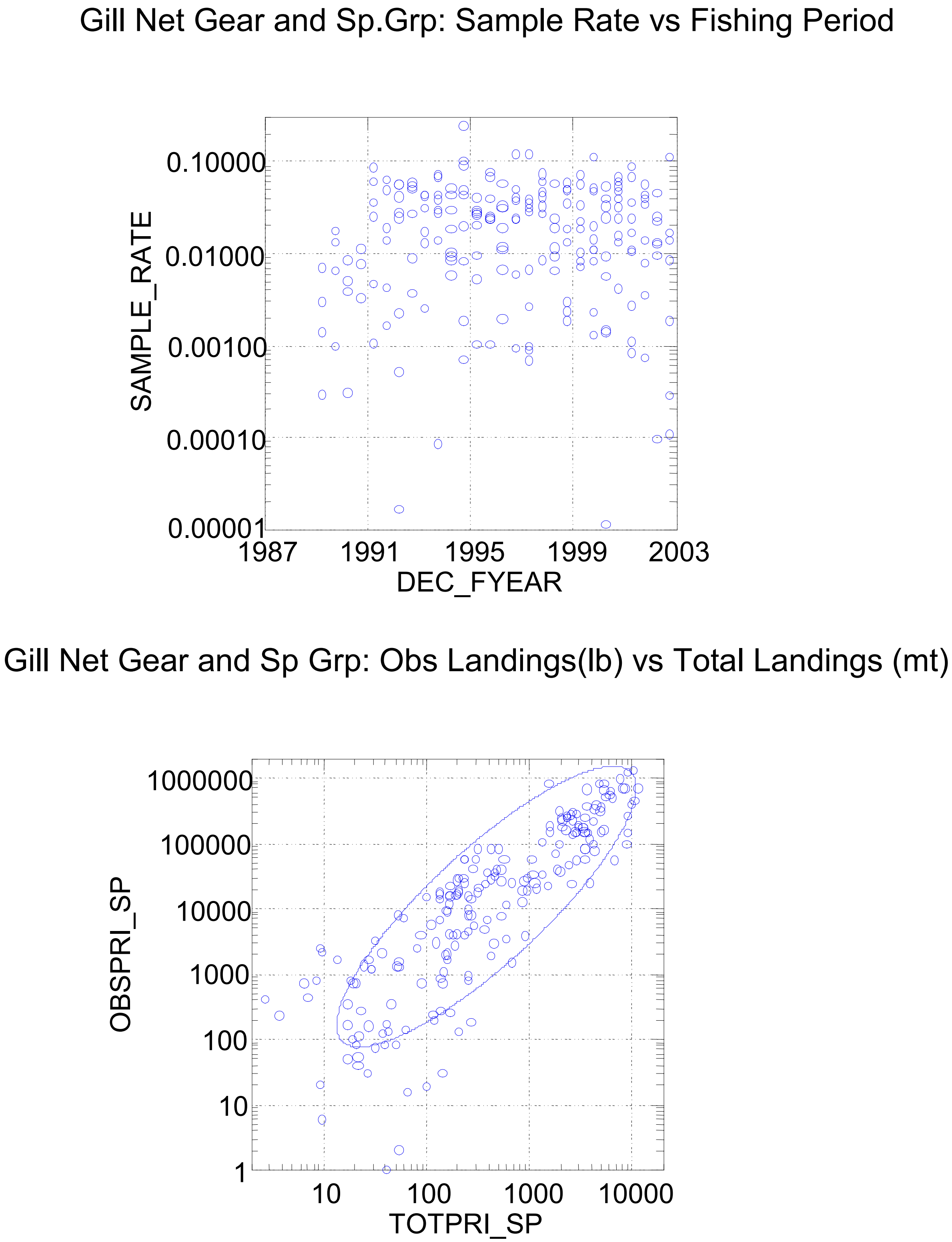
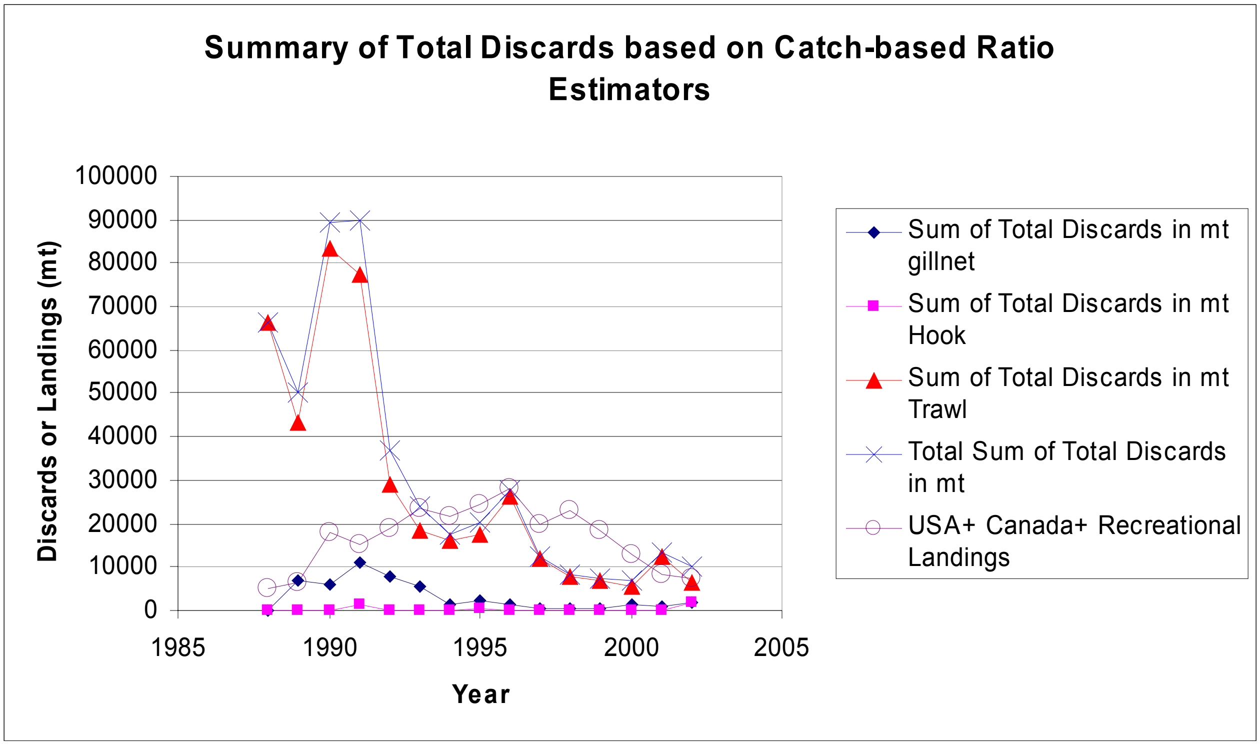


Fig. B4.14 Estimated sampling rate by month (denoted as decimal year) for each species group (top). Bottom panel illustrates relationship between total observed landings of primary species groups and total landings those groups in commercial dealer database. Landings on X axis are in mt. Observed landings on Y axis are in pounds. Only gill net gear. Confidence ellipse represents 0.68 probability level.



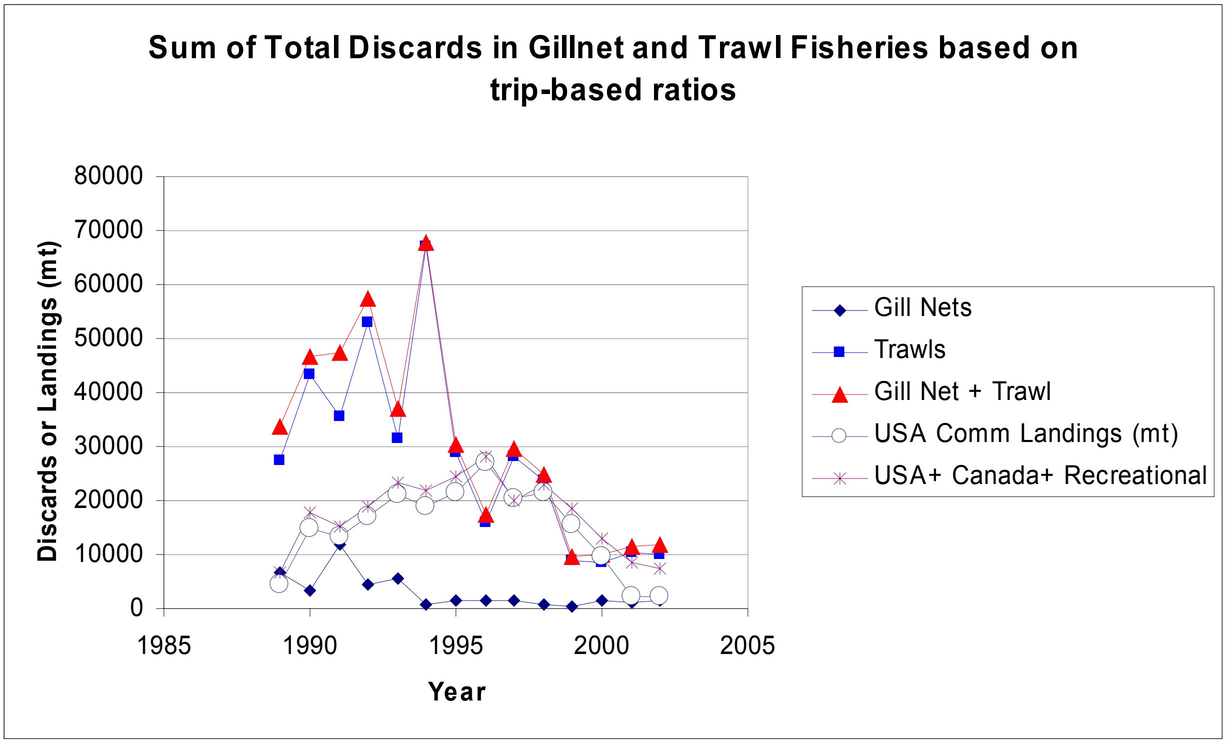


Fig. B4.15 Summary of total discard estimates based on catch ratio method (top) and comparisons with total landings in US, Canada and recreational fisheries, 1988-2002 fishing years. Bottom panel represents comparable estimates based on trip ratio estimator.

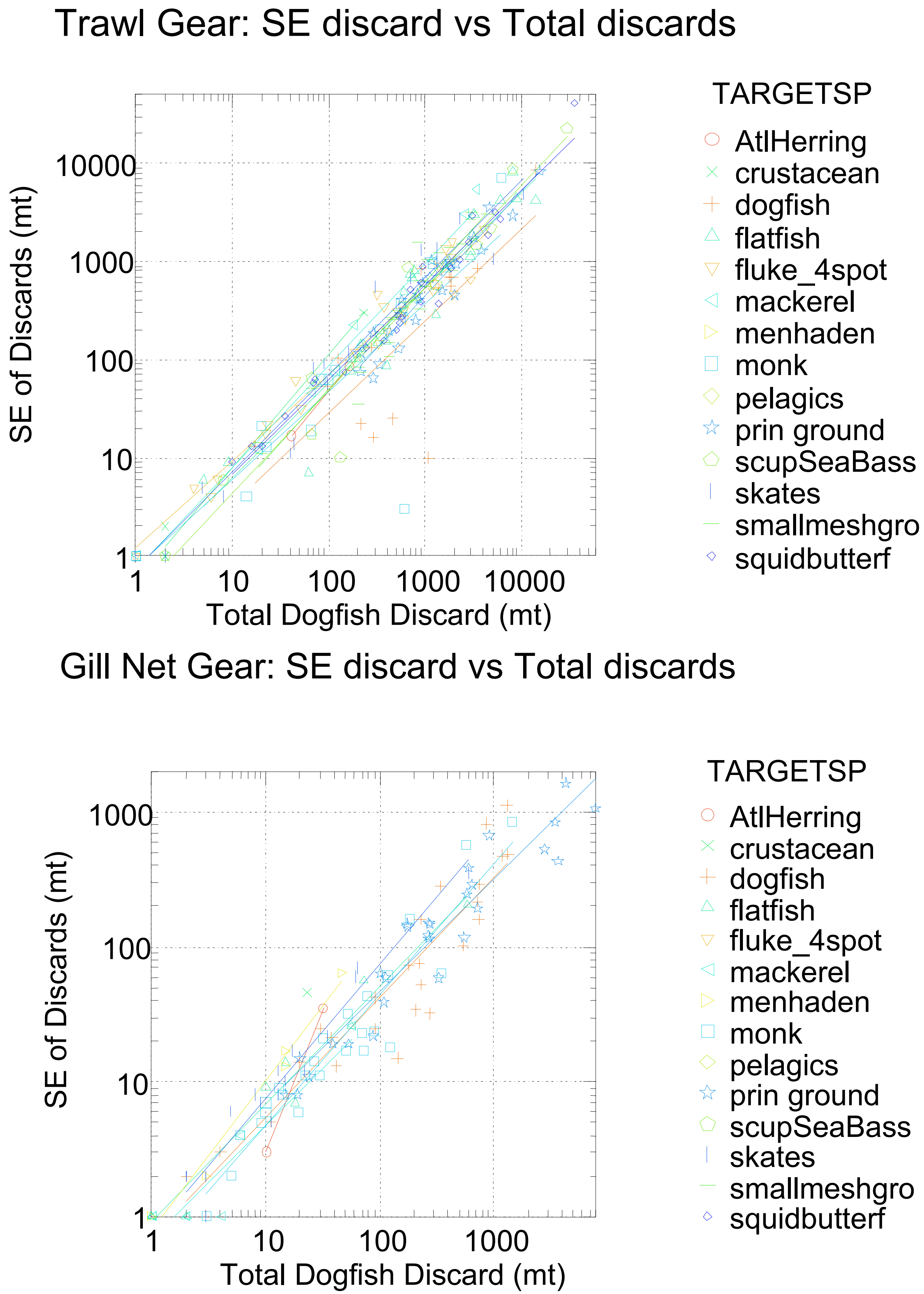


Fig. B4.16 Relationship between standard error of discard estimate and total discards by species group for trawl (top) and gill net (bottom) fisheries. All years combined.

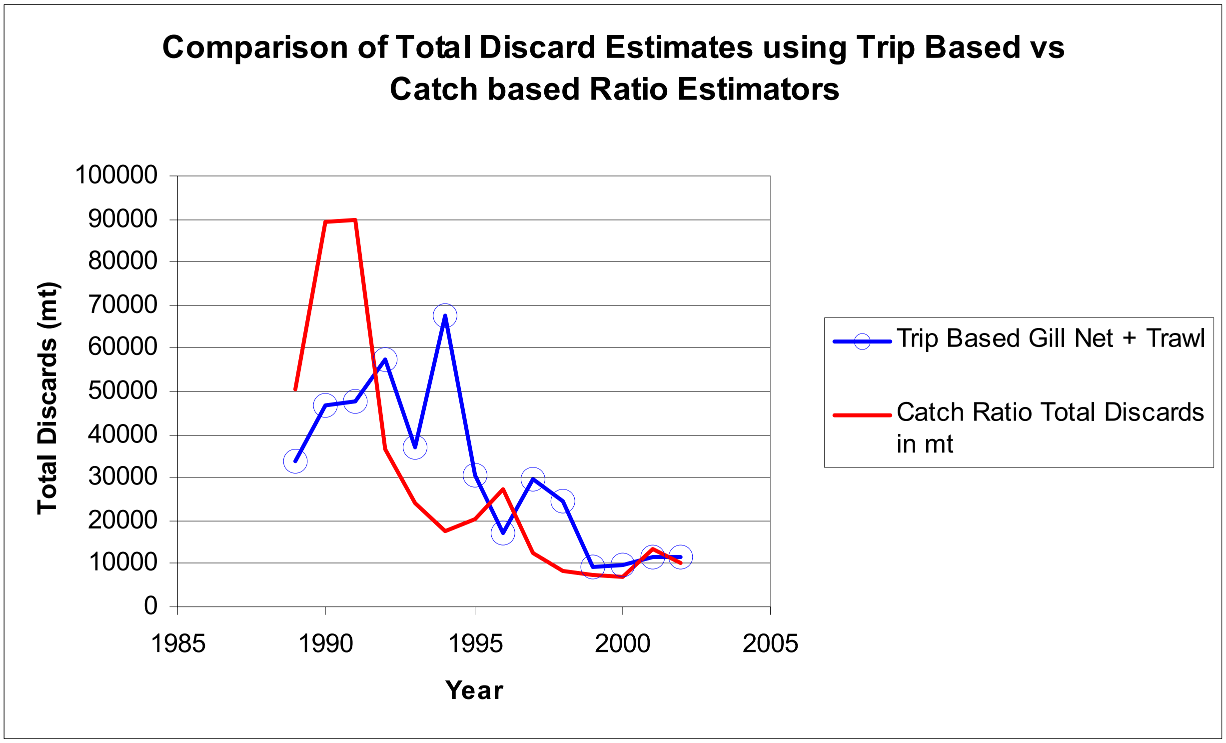
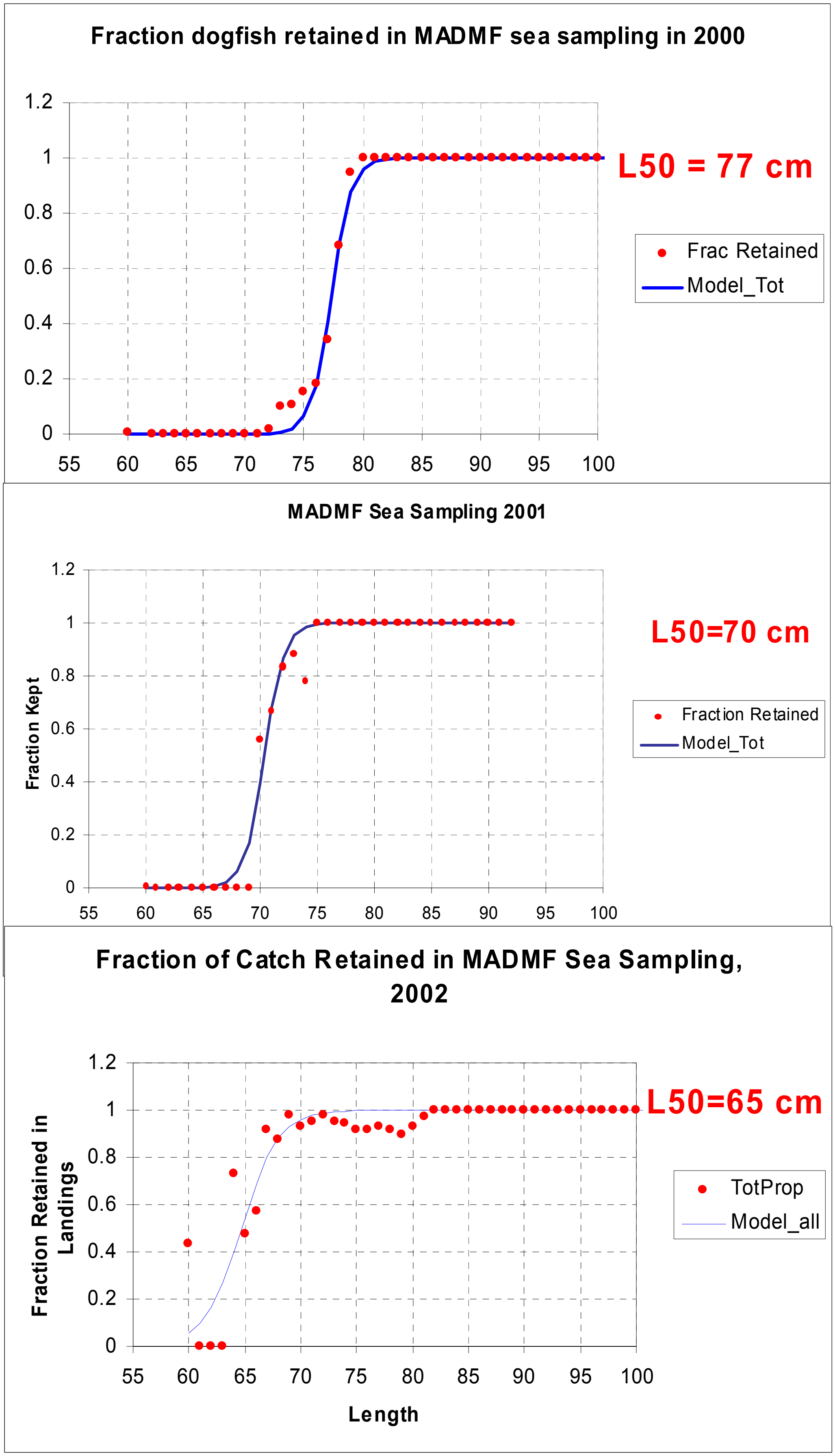


Fig. B4.17 Comparison of total discard estimates using catch ratio method with discard estimates using the trip-ratio method. Trip-based ratio estimator includes only gill net and trawl gear.



Fraction dogfish retained in MADMF sea sampling in 2000

L50 = 77 cm

MADMF Sea Sampling 2001

L50=70 cm

Fraction of Catch Retained in MADMF Sea Sampling, 2002

L50=65 cm

Fig. B4.18. Results of MADMF sea sampling data, 2000-02. Functions represent fits of logistic model to fraction retained by size class.

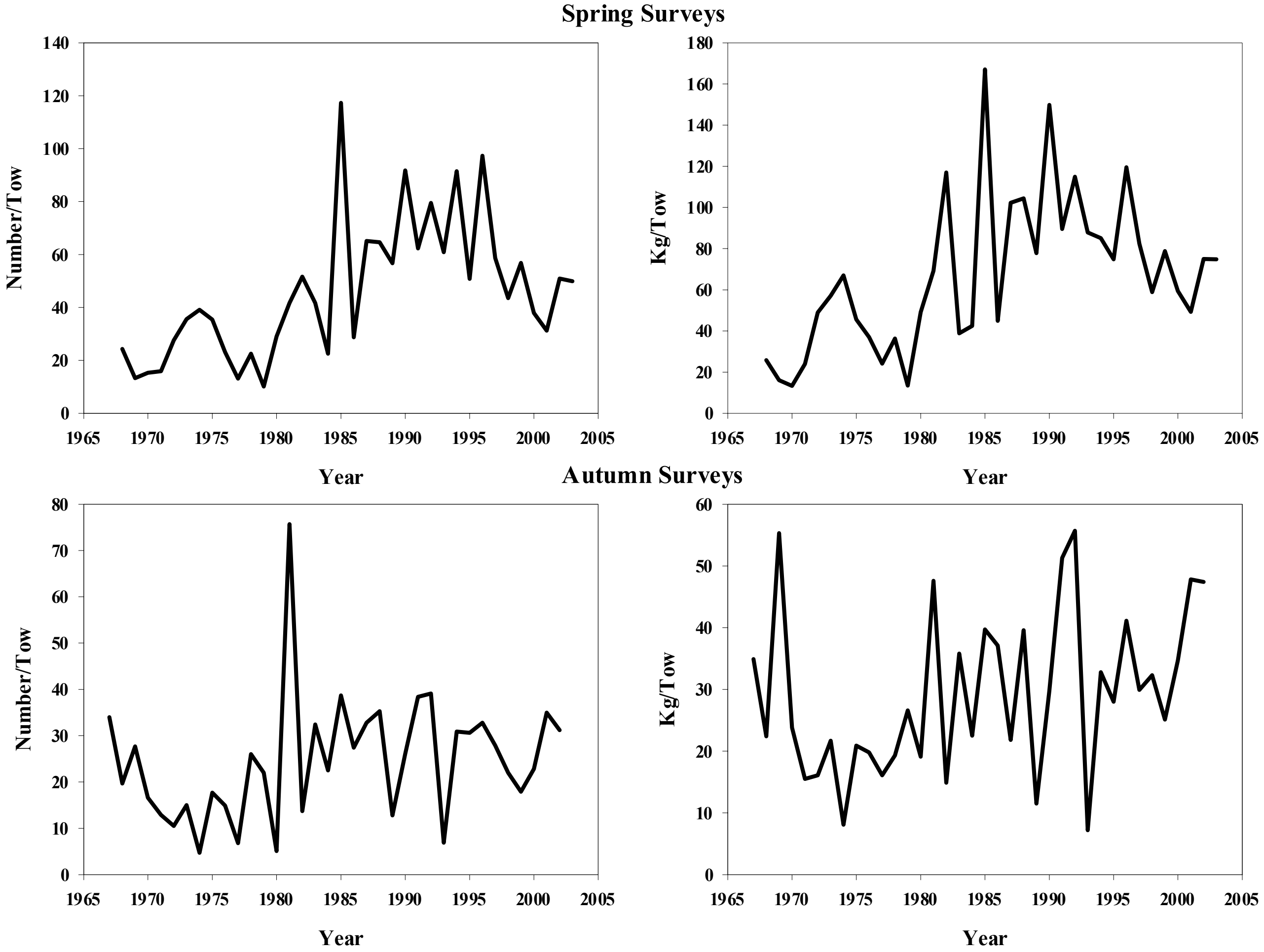


Figure B5.1. Abundance (stratified mean catch per tow in numbers) and biomass (stratified mean catch per tow in kilograms) indices of spiny dogfish from the NEFSC spring survey, 1968-2003, and autumn survey, 1967-2002 (Offshore strata 1-30, 33-40, 61-76.

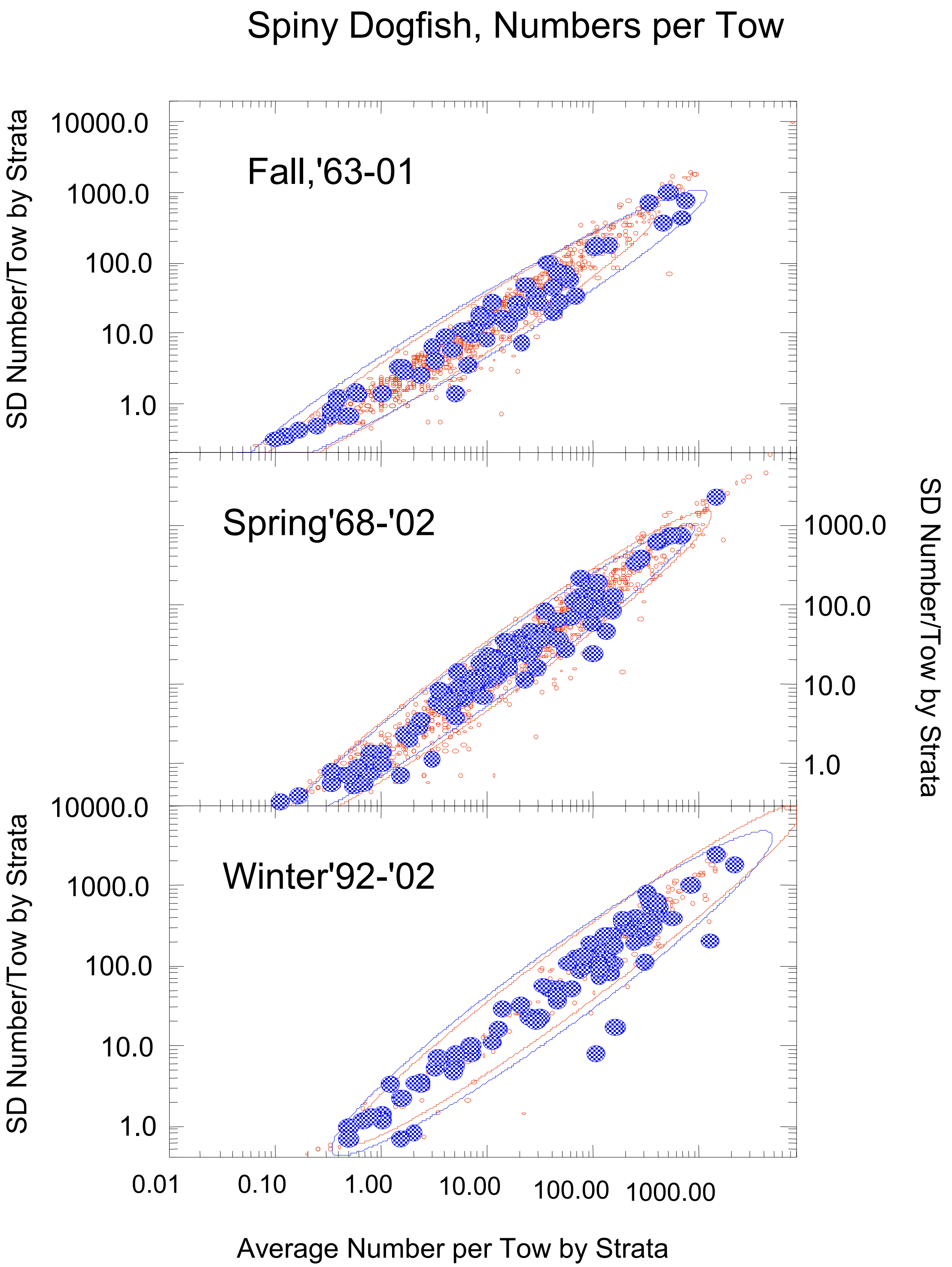


Figure B5.2. Standard deviation of catch in numbers vs. mean catch (#/tow) for Spiny Dogfish in NEFSC fall, spring and winter trawl surveys. Each dot represents a stratum. Small open dots represent data from 1999 and earlier, large solid circles represent data from 2000-02. Confidence ellipses (95%) are drawn for pre and post warp offset treatment period.

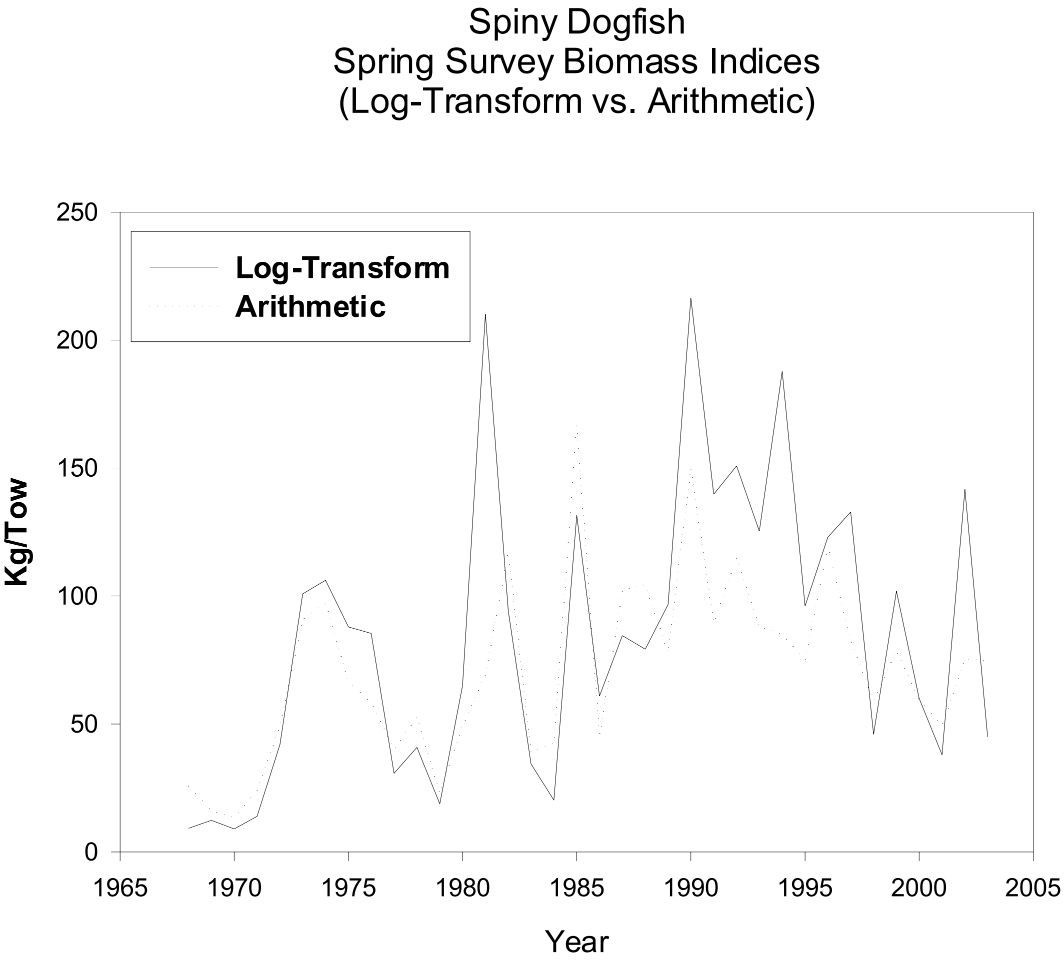


Figure B5.3. Biomass (stratified mean catch per tow in kilograms) indices of spiny dogfish comparing arithmetic and log-transformed means from the NEFSC spring survey, 1968-2003 (Offshore strata 1-30, 33-40, 61-76.

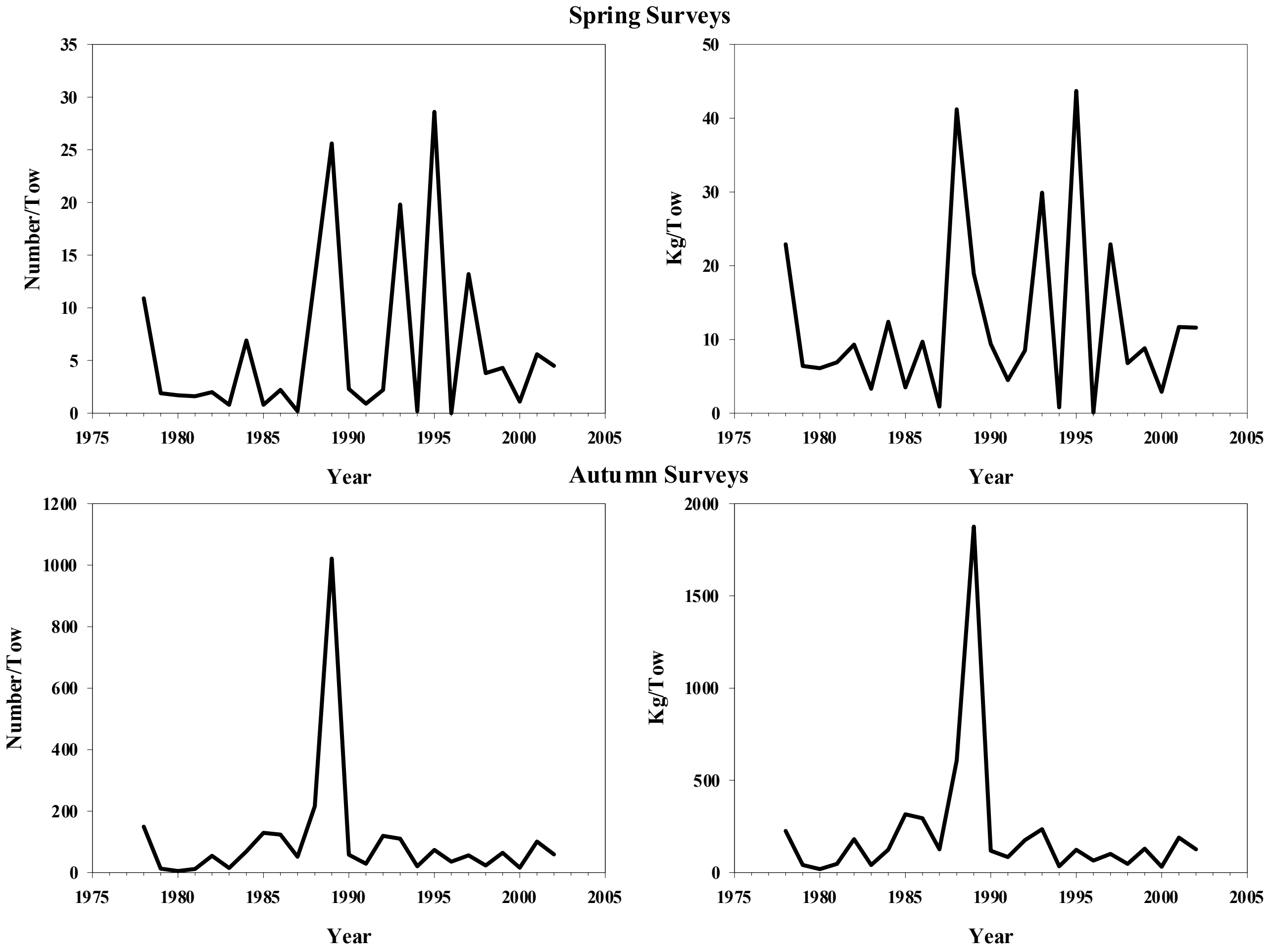


Figure B5.4 Abundance (mean catch per tow in numbers) and biomass (mean catch per tow in kilograms) indices of spiny dogfish from the Massachusetts spring and autumn surveys, 1978-2002.

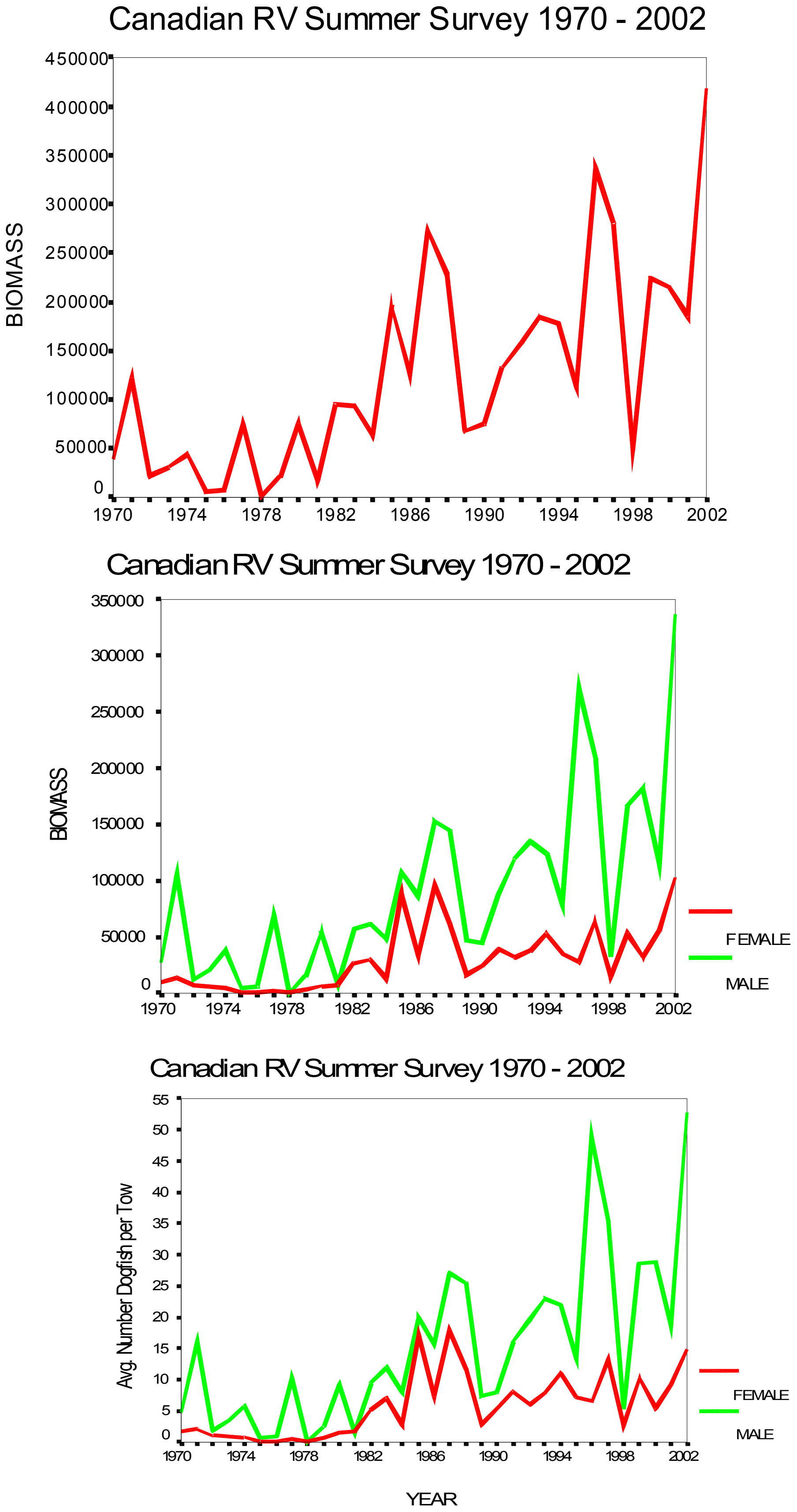


Fig. B5.5 Summary of abundance trends for spiny dogfish captured in Canadian R/V trawl surveys. Data provided courtesy of Steve Campana, DFO, Halifax.

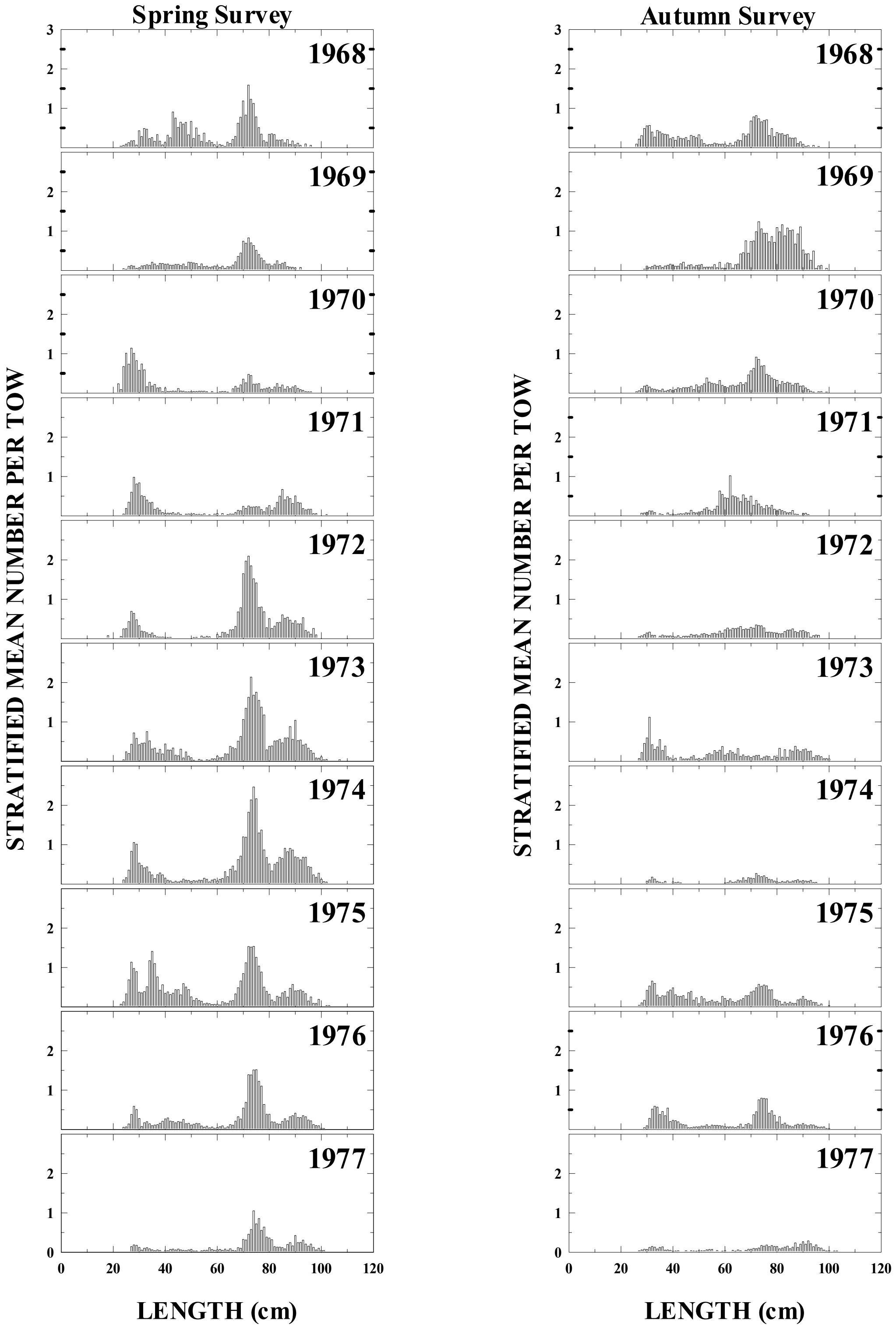


Figure B5.6.a. Length composition of spiny dogfish from the NEFSC spring and autumn bottom trawl survey, 1968-1977 (Offshore strata 1-30, 33-40, 61-76).

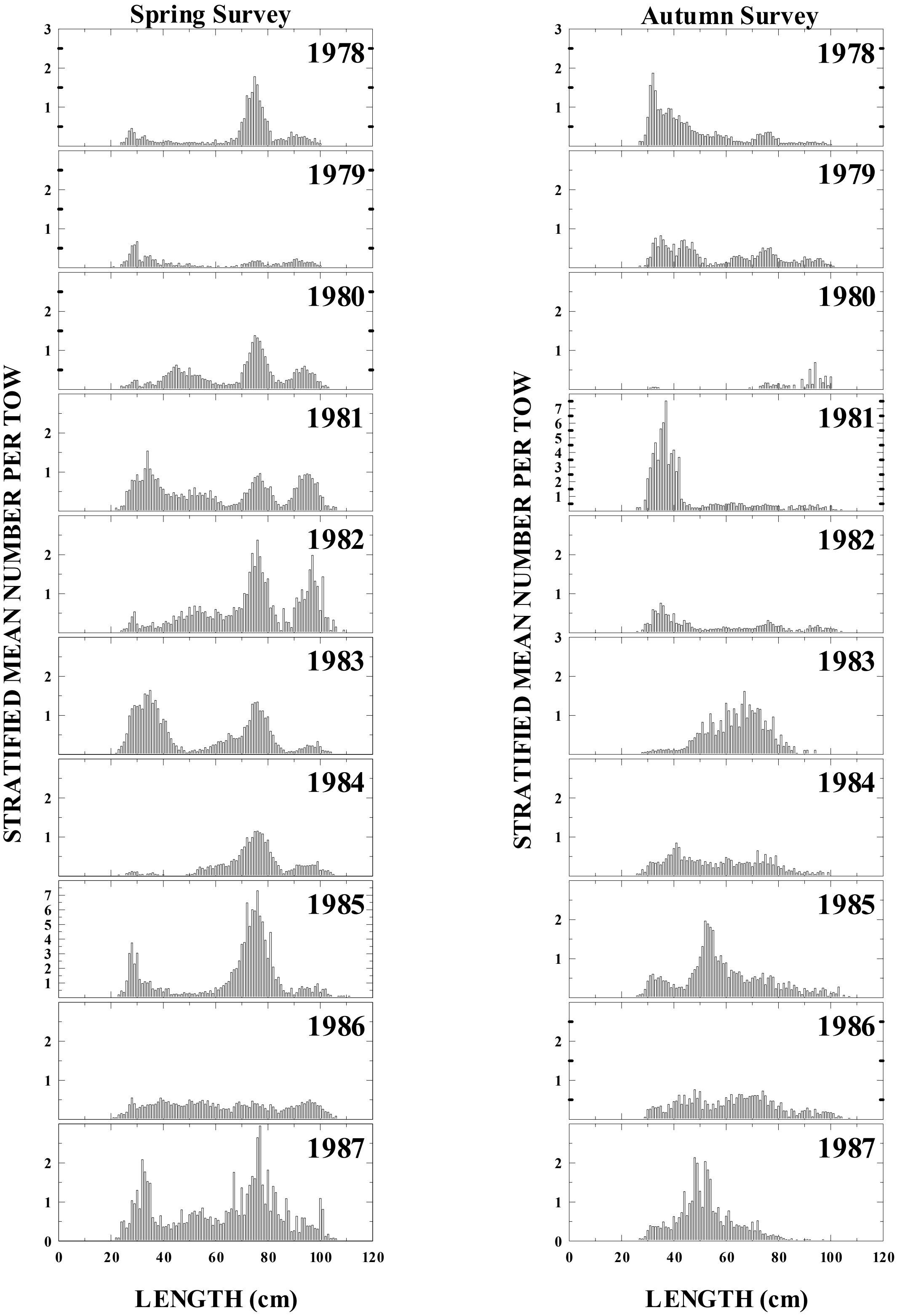


Figure B5.6 b. Length composition of spiny dogfish from the NEFSC spring and autumn bottom trawl survey, 1978-1987 (Offshore strata 1-30, 33-40, 61-76). Note the scales for spring 1985 and autumn 1981 are higher.

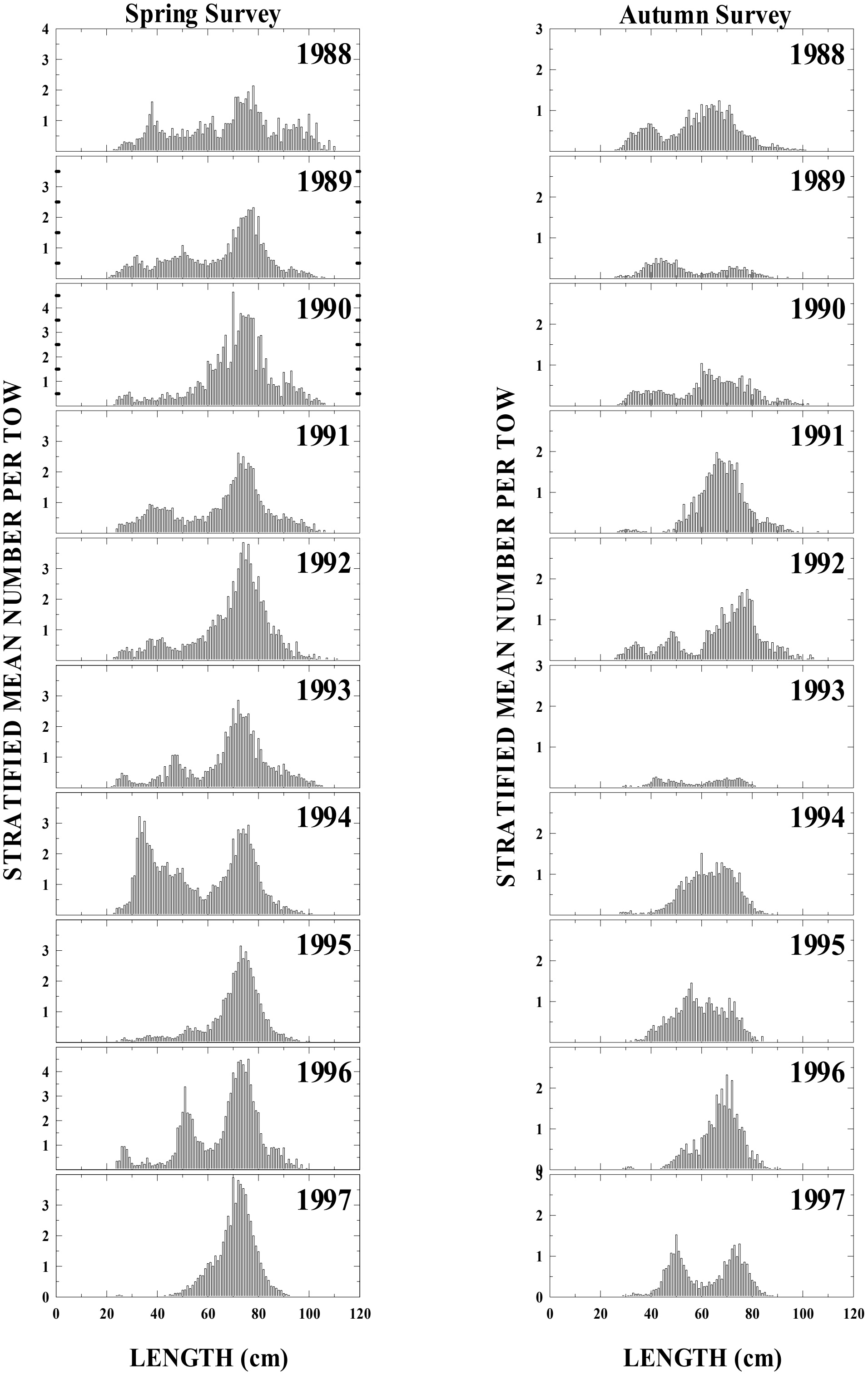
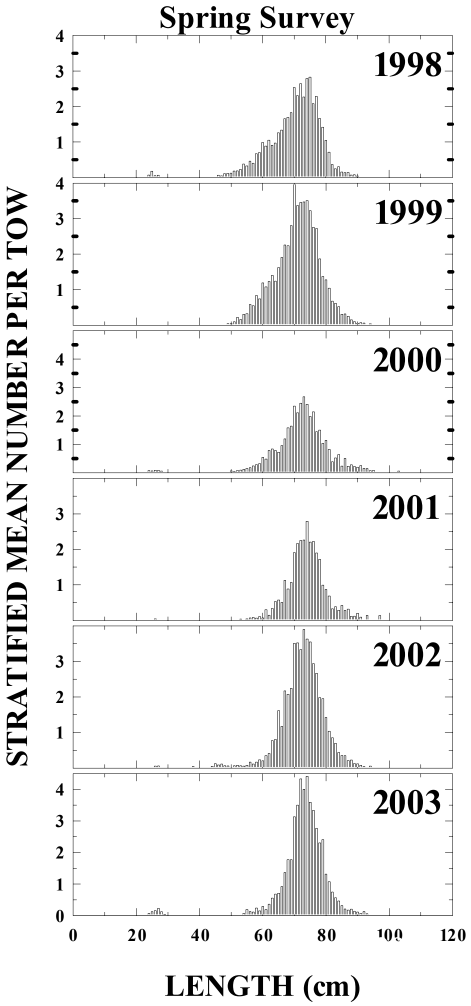


Figure B5.6 c. Length composition of spiny dogfish from the NEFSC spring and autumn bottom trawl survey, 1988-1997 (Offshore strata 1-30, 33-40, 61-76). Note the scales for spring and autumn differ and spring 1990 and 1996 are also different..



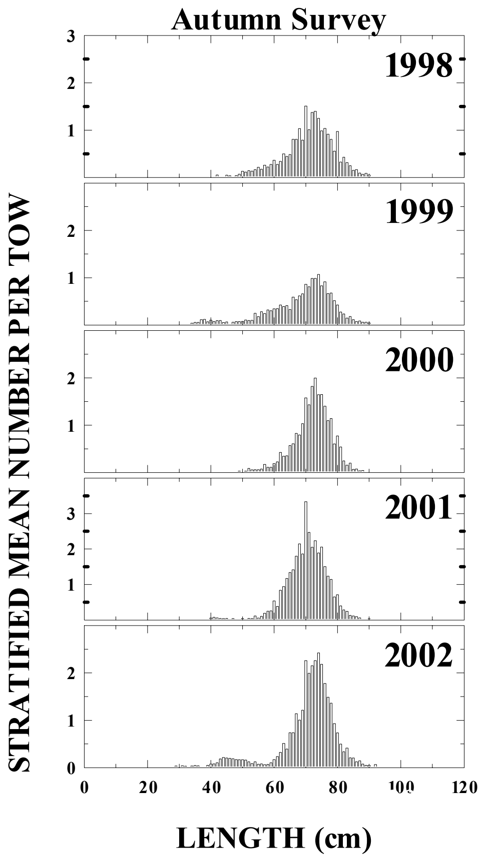


Figure B5.6d. Length composition of spiny dogfish from the NEFSC spring and autumn bottom trawl survey, 1998-2003 (Offshore strata 1-30, 33-40, 61-76). Note the scales for spring and autumn differ and spring 2002 and autumn 2001 are also different.

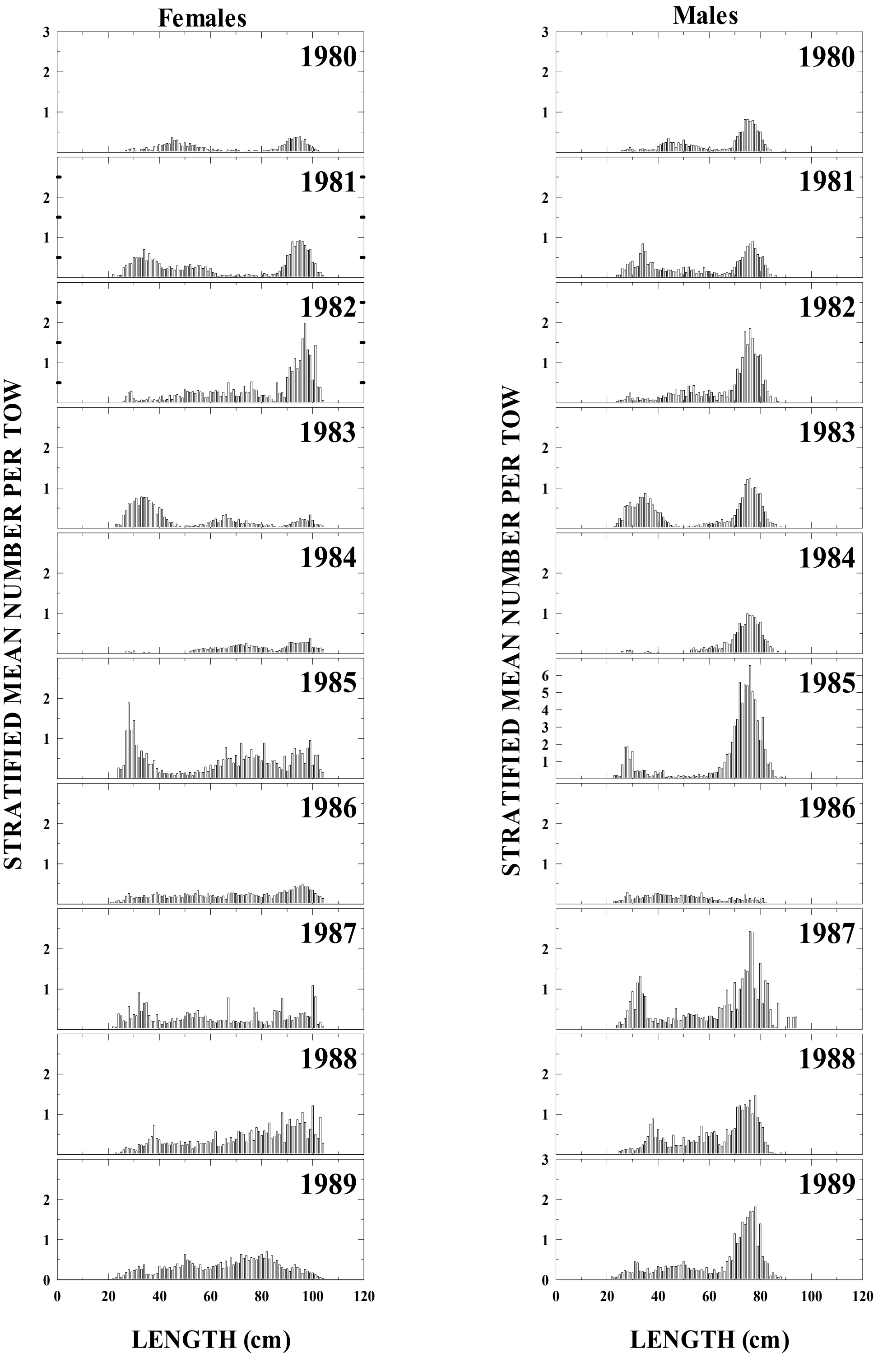


Figure B5.7 a. Length composition of male and female spiny dogfish from the NEFSC spring bottom trawl surveys, 1980-1989 (Offshore strata 1-30, 33-40, 61-76). Note the scale for males in 1985 is larger.

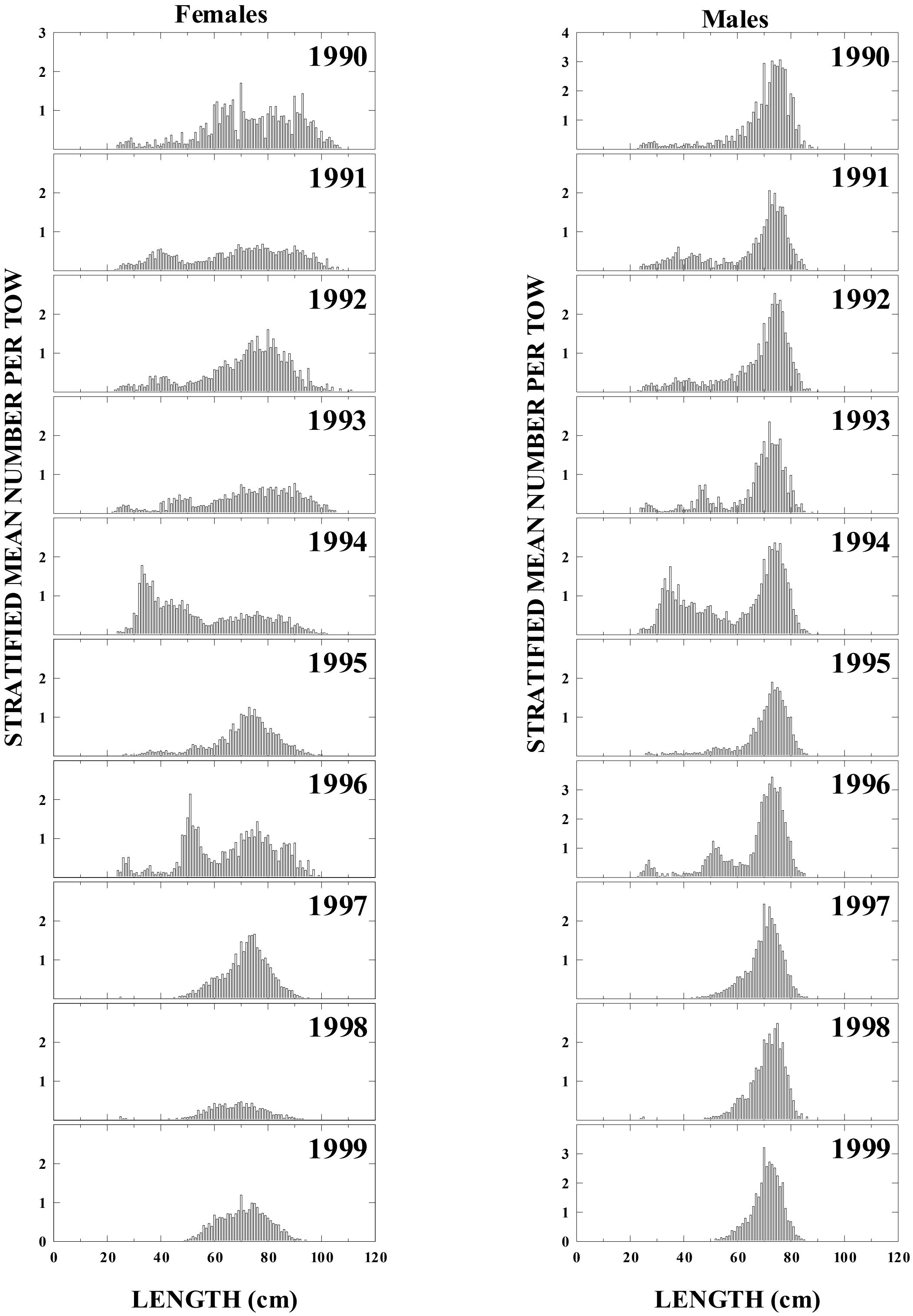


Figure B5.7 b. Length composition of male and female spiny dogfish from the NEFSC spring bottom trawl surveys, 1989-1999 (Offshore strata 1-30, 33-40, 61-76). Note the scales for males in 1990, 1996, and 1999 are larger.

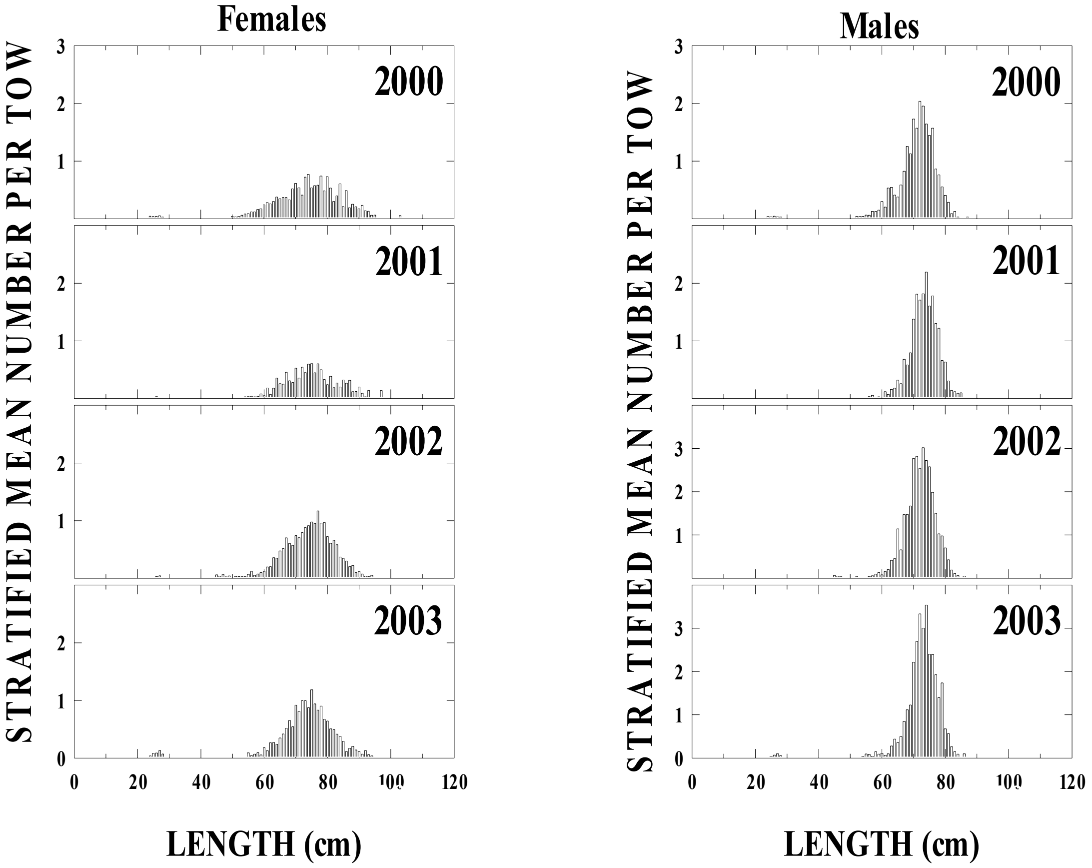


Figure B5.7 c. Length composition of male and female spiny dogfish from the NEFSC spring bottom trawl surveys, 2000-2003 (Offshore strata 1-30, 33-40, 61-76). Note the scale for males in 2002 is different.

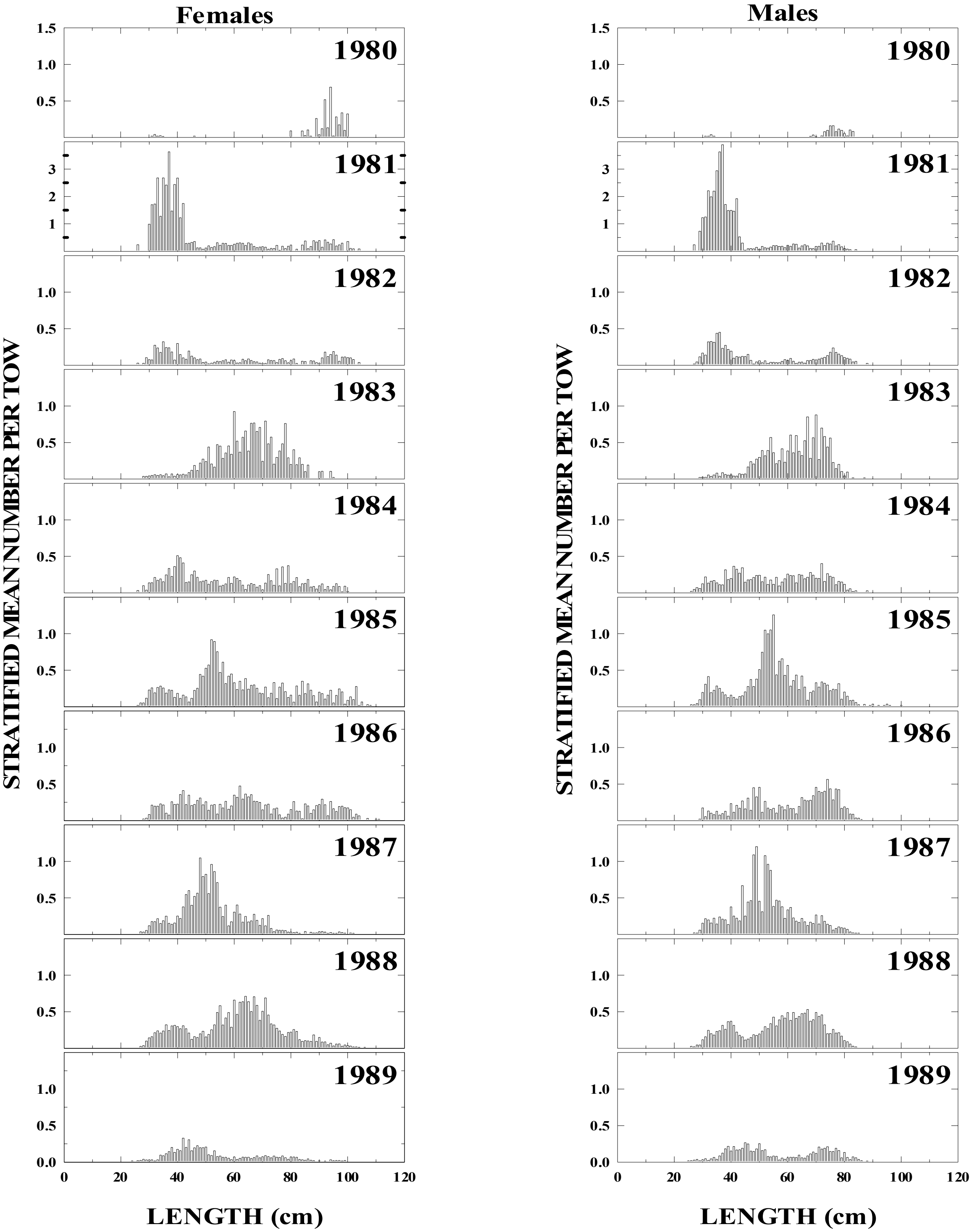


Figure B5.8 a. Length composition of male and female spiny dogfish from the NEFSC autumn bottom trawl surveys, 1980-1989 (Offshore strata 1-30, 33-40, 61-76). Note the scale for males in 1981 is larger.

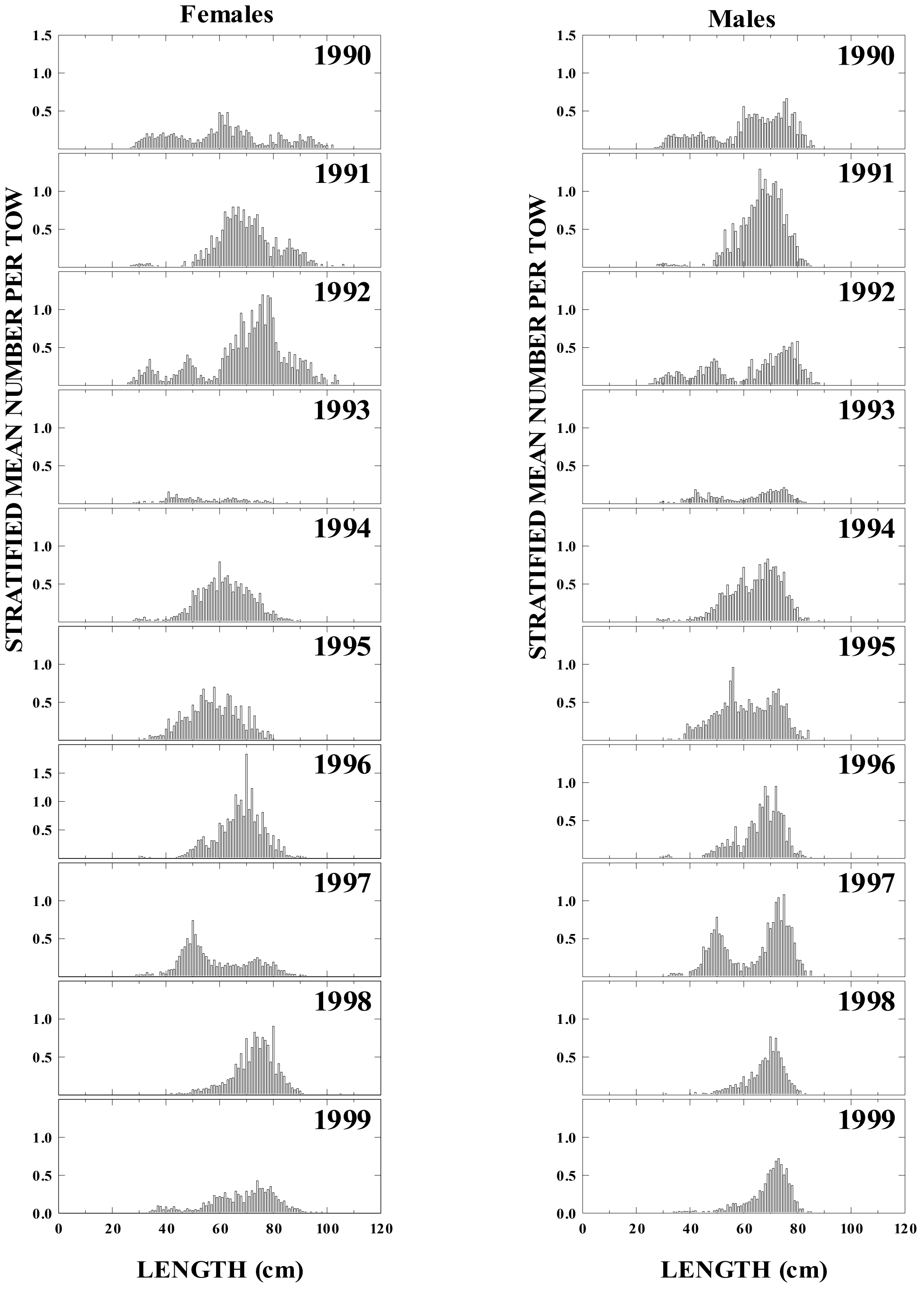


Figure B5.8 b. Length composition of male and female spiny dogfish from the NEFSC autumn bottom trawl surveys, 1990-1999 (Offshore strata 1-30, 33-40, 61-76). Note the scale for females in 1996 is larger.

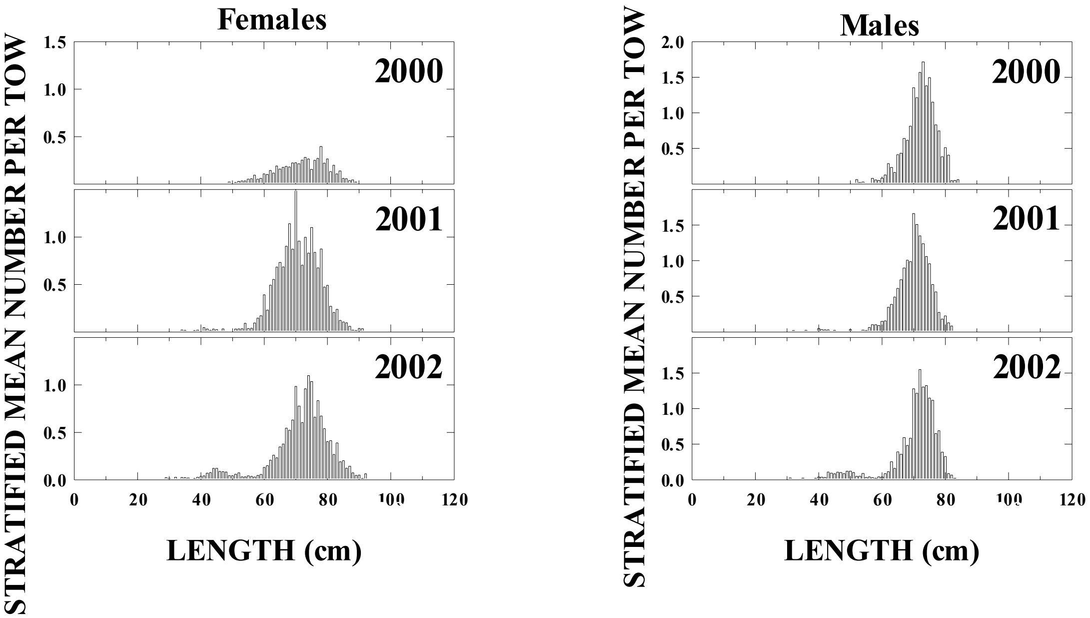


Figure B5.8c. Length composition of male and female spiny dogfish from the NEFSC autumn bottom trawl surveys, 2000-2002 (Offshore strata 1-30, 33-40, 61-76). Note the scale for males is different from previous figures.

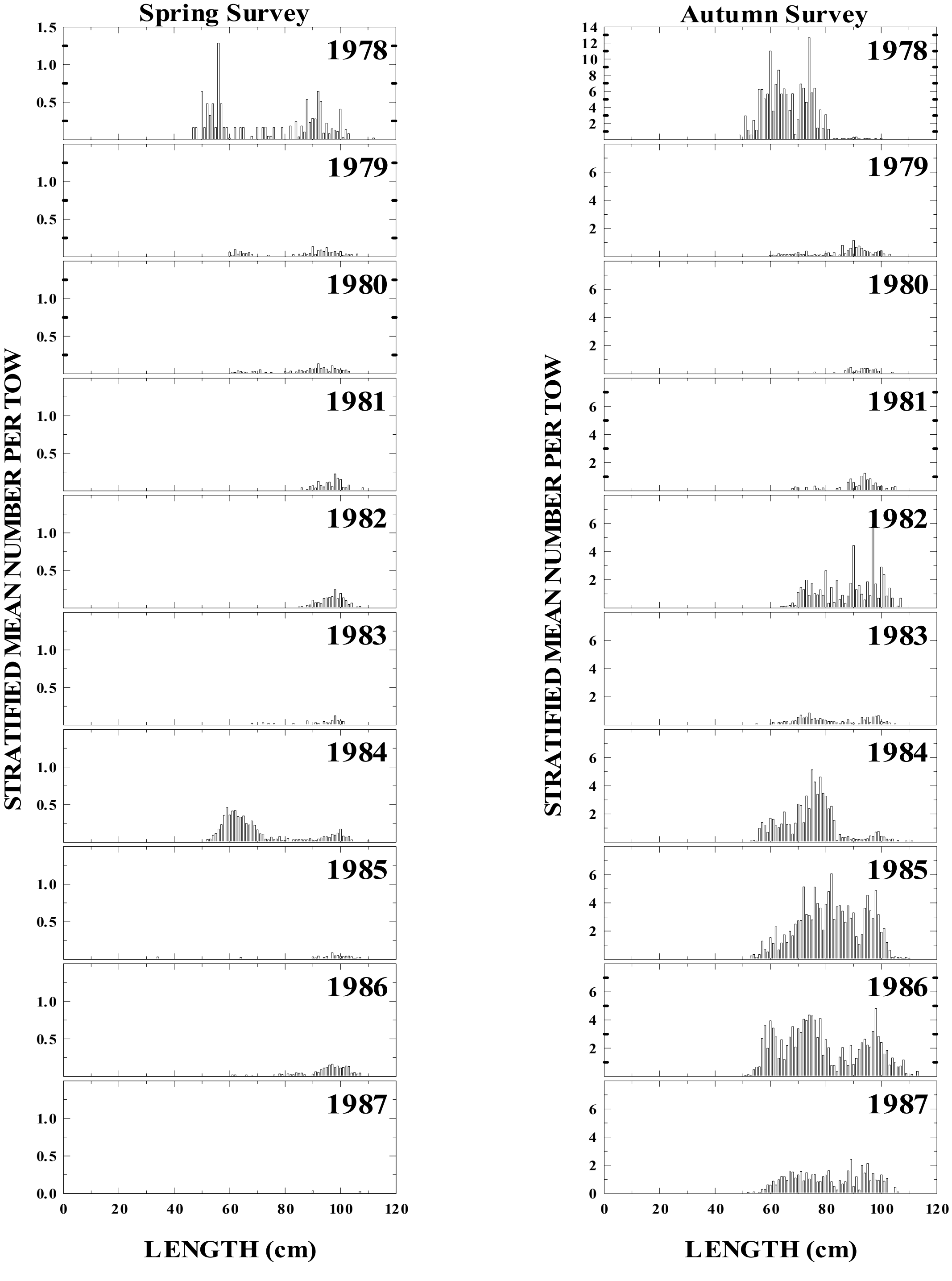


Figure B5.9 a. Length composition of spiny dogfish from the Massachusetts spring and autumn bottom trawl surveys, 1978-1987. Note the scales for spring and autumn differ and autumn 1978 is higher.

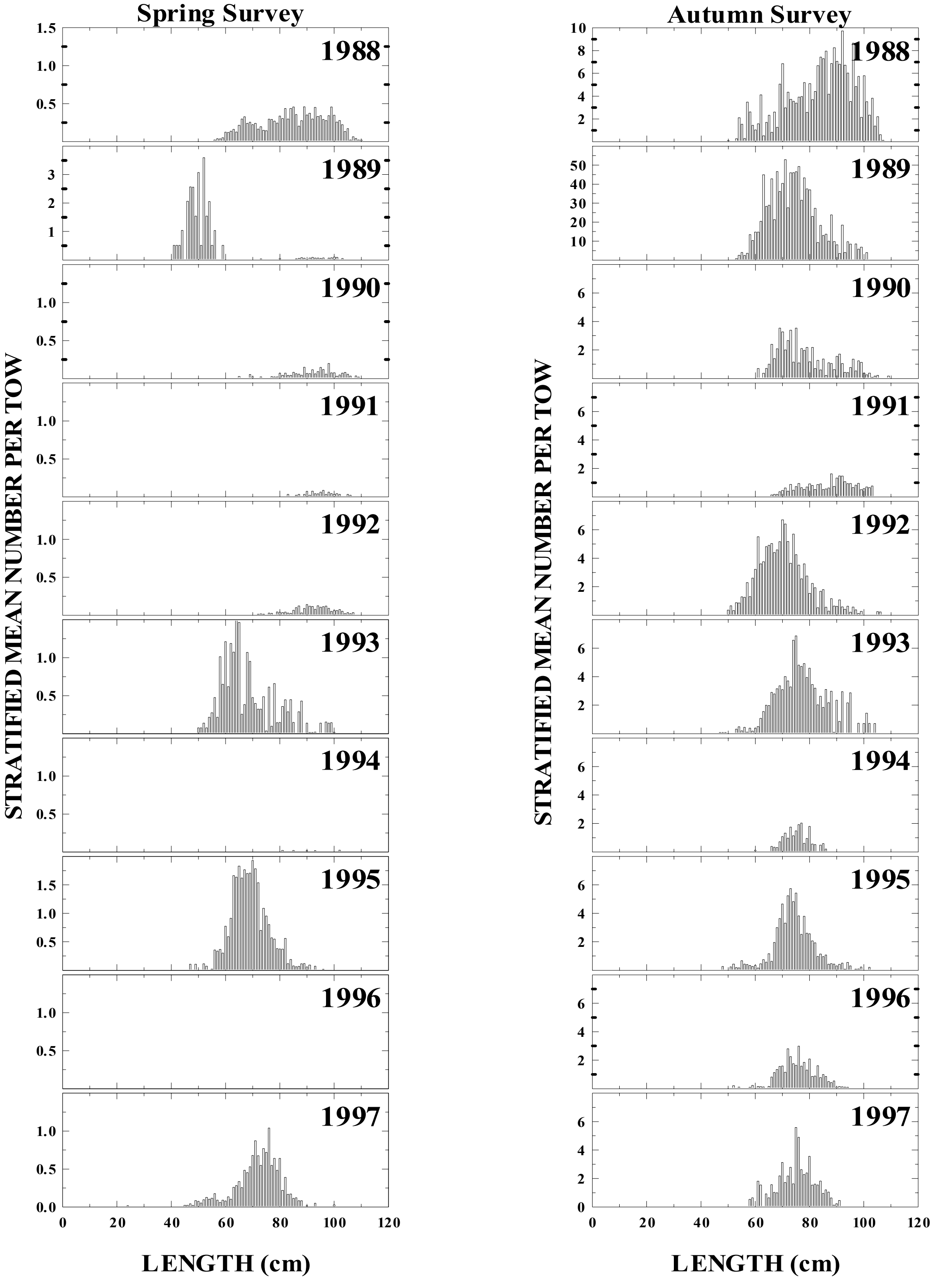


Figure B5.9 b. Length composition of spiny dogfish from the Massachusetts spring and autumn bottom trawl surveys, 1988-1997. Note the scales for spring and autumn differ and spring (1989,1995) autumn (1988,1989) are also different.

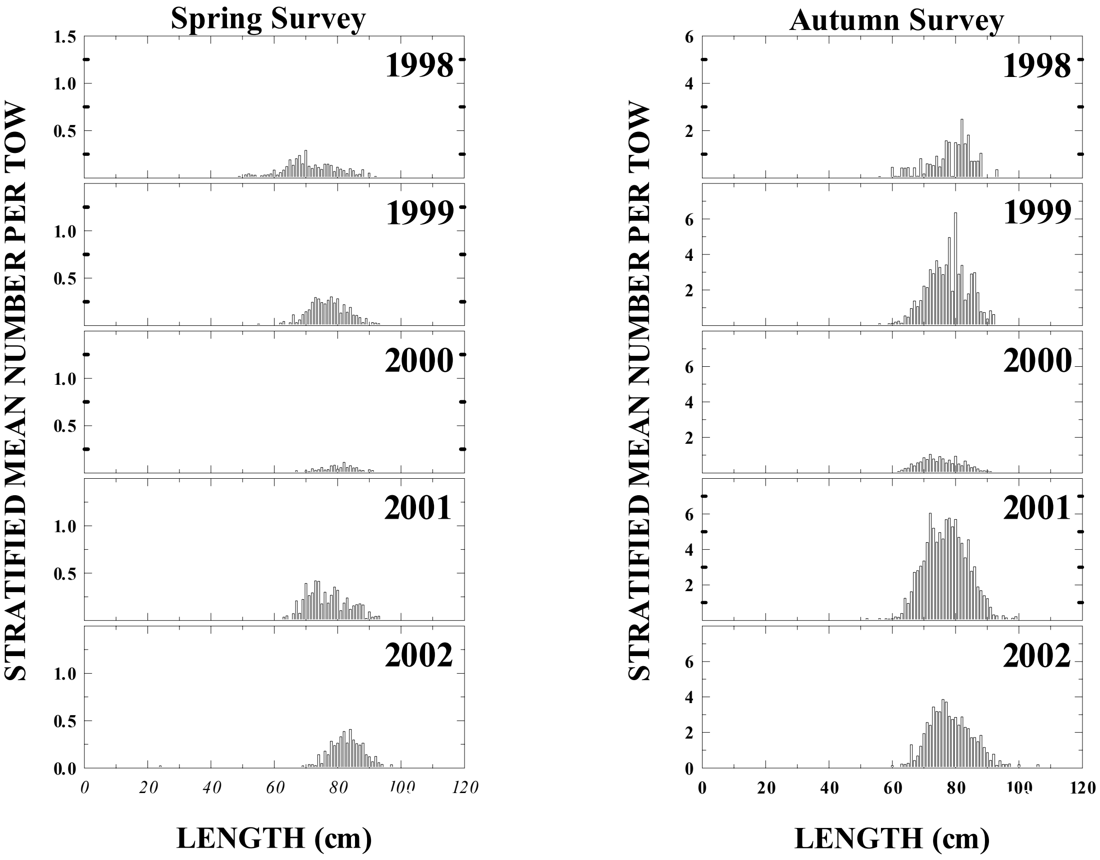


Figure B5.9c. Length composition of spiny dogfish from the Massachusetts spring and autumn bottom trawl surveys, 1998-2002.

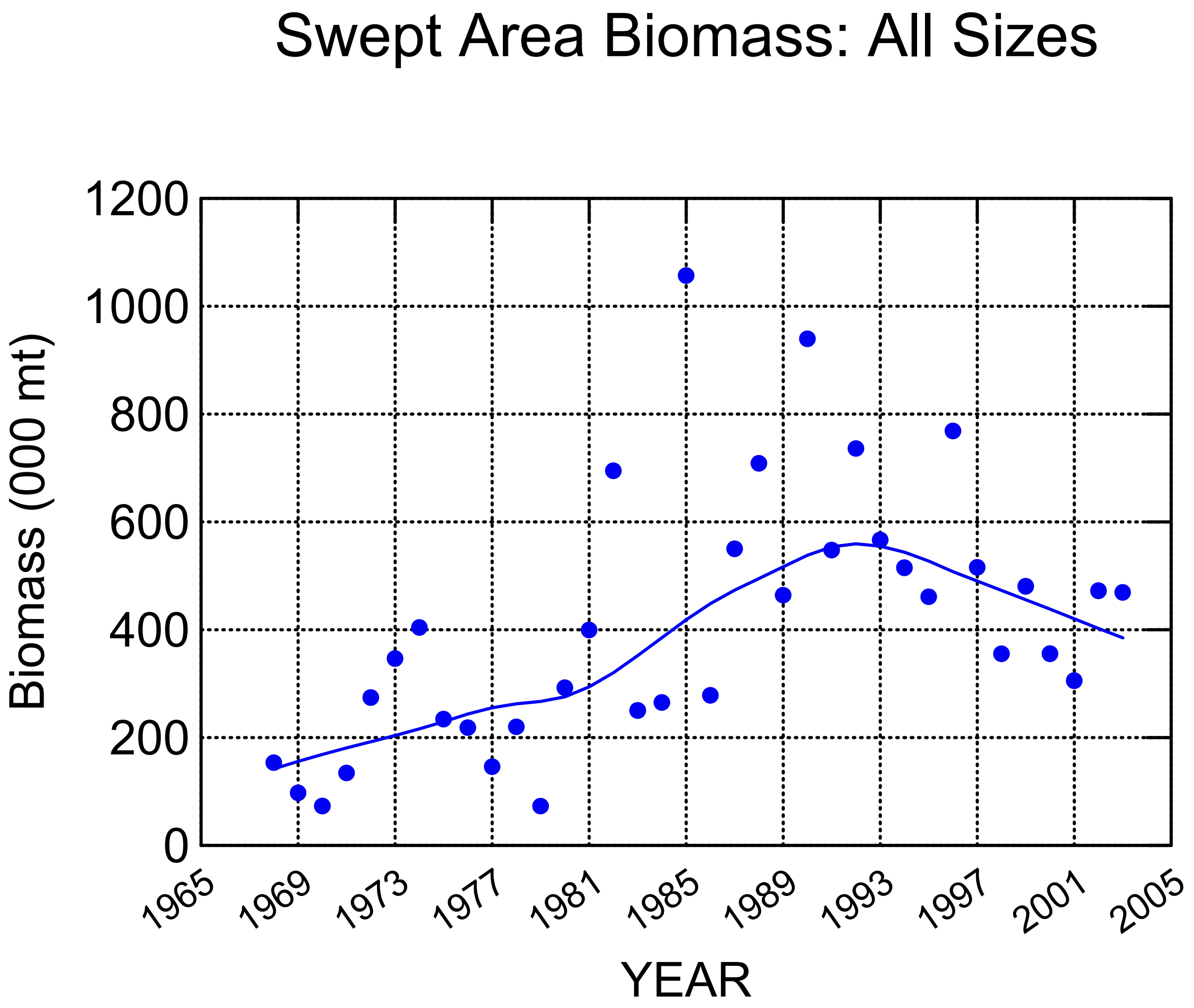
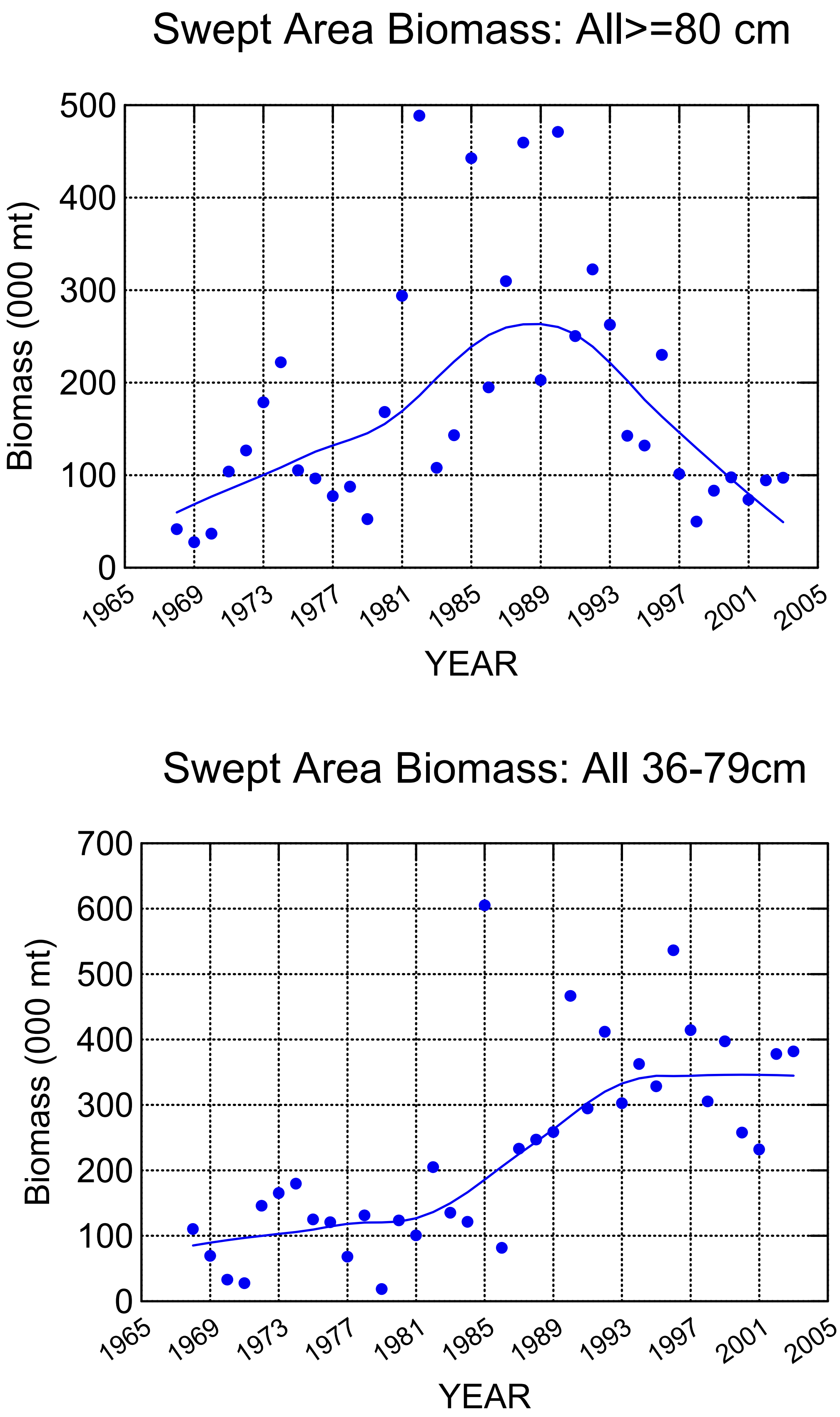


Fig. 6.1 Swept area estimate of total dogfish biomass (000 mt) in spring R/V trawl survey, 1968-2003. Line represents Lowess smooth with tension factor = 0.5.


Swept Area Biomass: All>=80 cm

Swept Area Biomass: All 36-79cm

Fig. 6.2 Swept area estimate of dogfish biomass (000 mt) in spring R/V trawl survey, 1968-2003 for dogfish greater than 80 cm (top) and 36-79 cm (bottom). Both sexes combined. Line represents Lowess smooth with tension factor = 0.5.

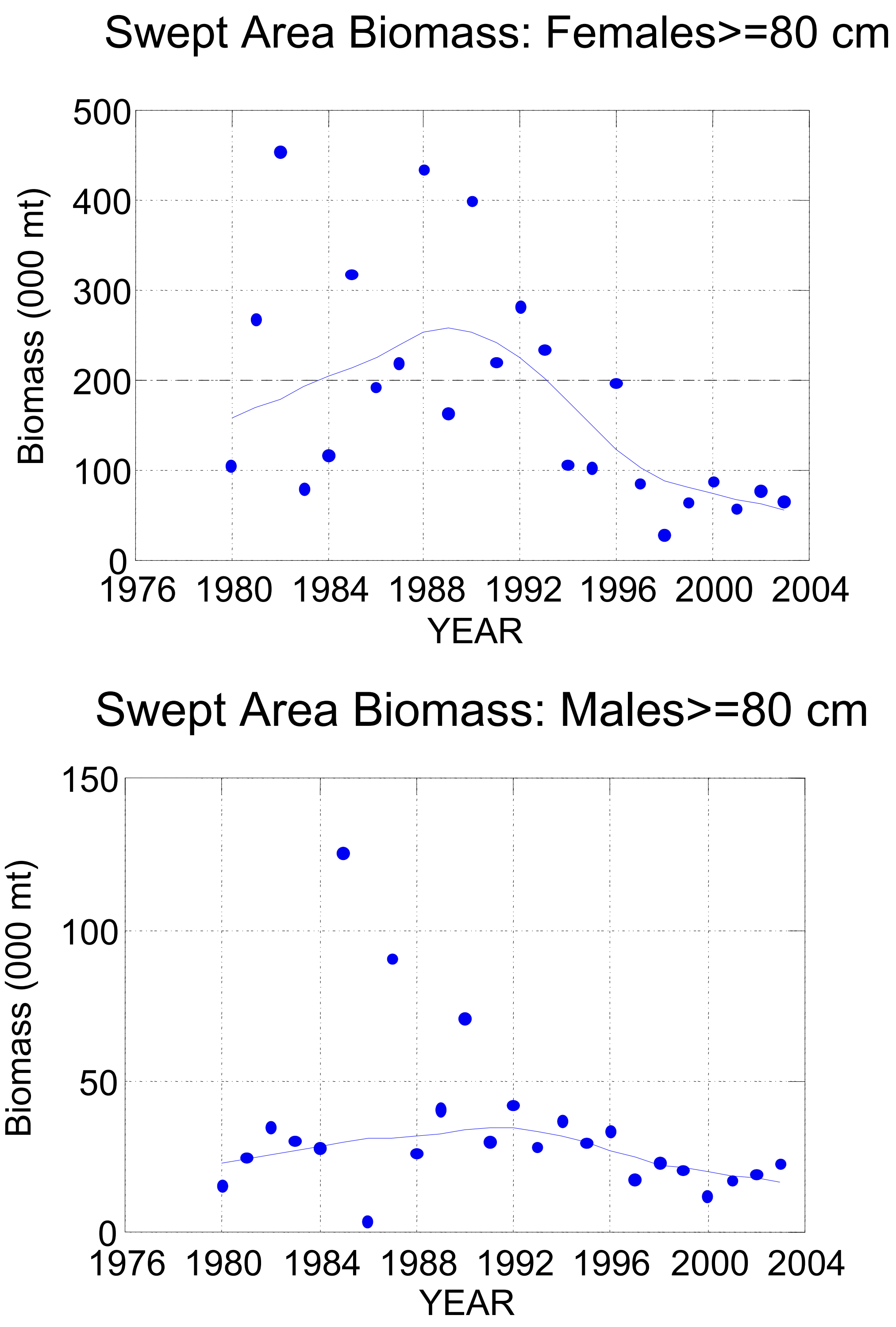


Fig. B6.3 Swept area estimate of dogfish biomass (000 mt) by sex in spring R/V trawl survey, 1980-2003 for dogfish greater than 80 cm, Females (top) and males (bottom). Line represents Lowess smooth with tension factor = 0.5.

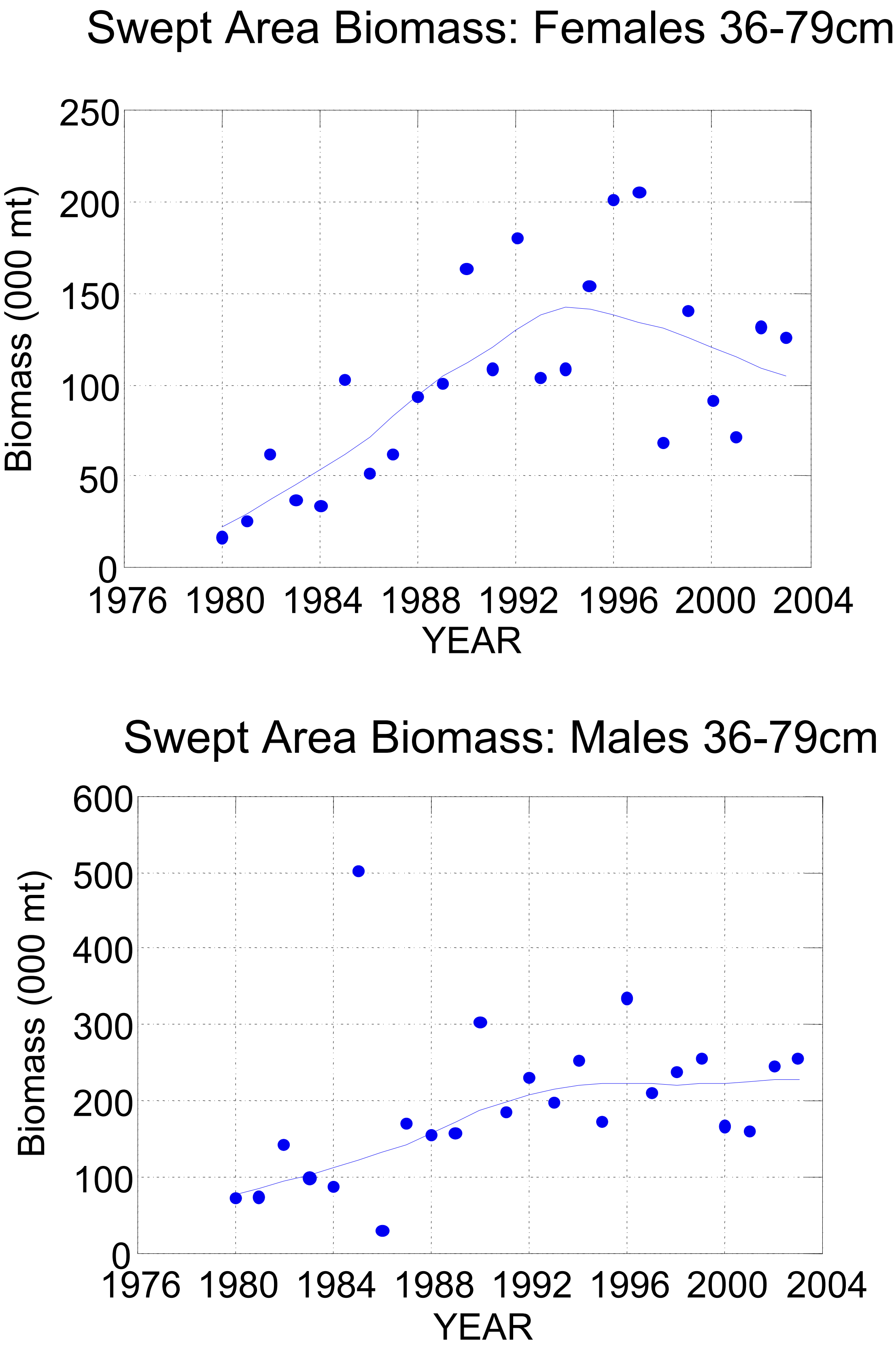


Fig. B6.4 Swept area estimate of dogfish biomass (000 mt) by sex in spring R/V trawl survey, 1980-2003 for dogfish between 36-79 cm, Females (top) and males (bottom). Line represents Lowess smooth with tension factor = 0.5.

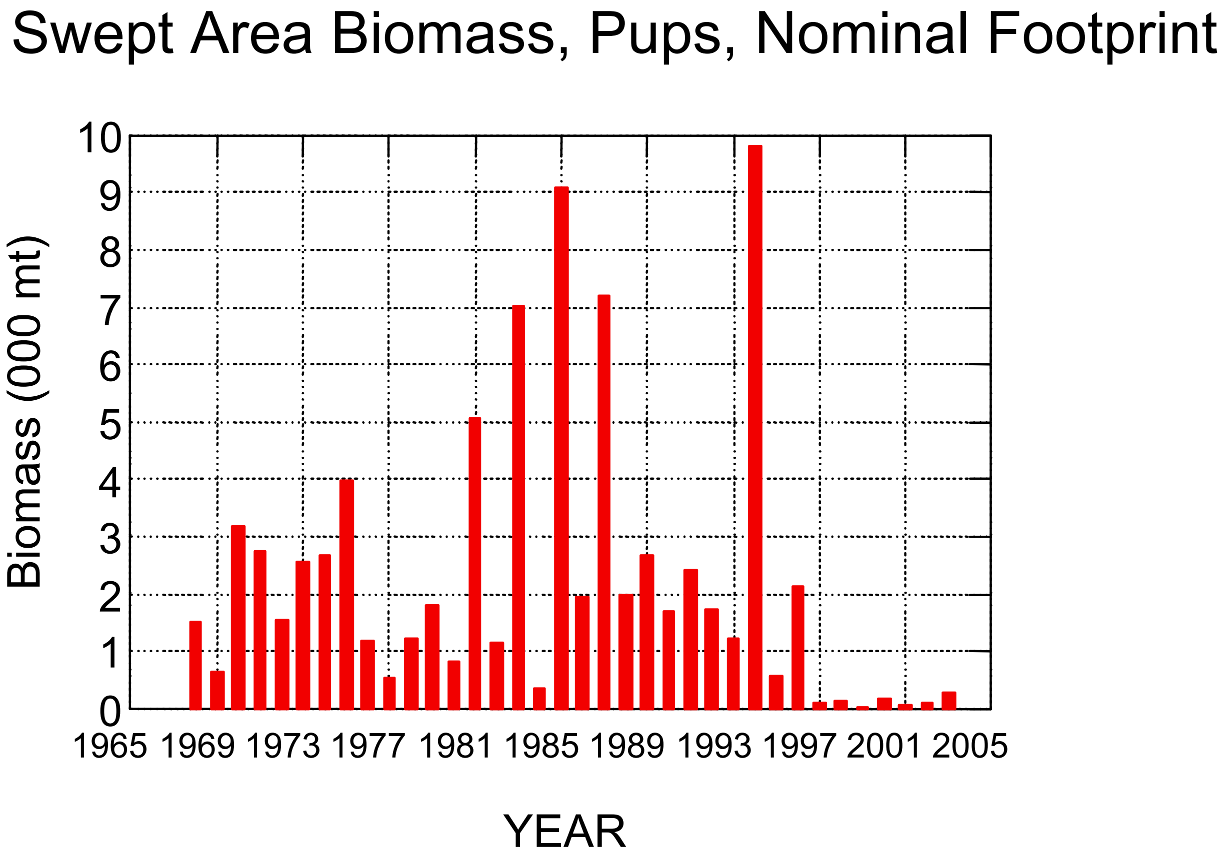


Fig. B6.5 Swept area estimate of dogfish biomass (000 mt) recruits in spring R/V trawl survey, 1968-2003. Recruits defined as individuals less than 36 cm.

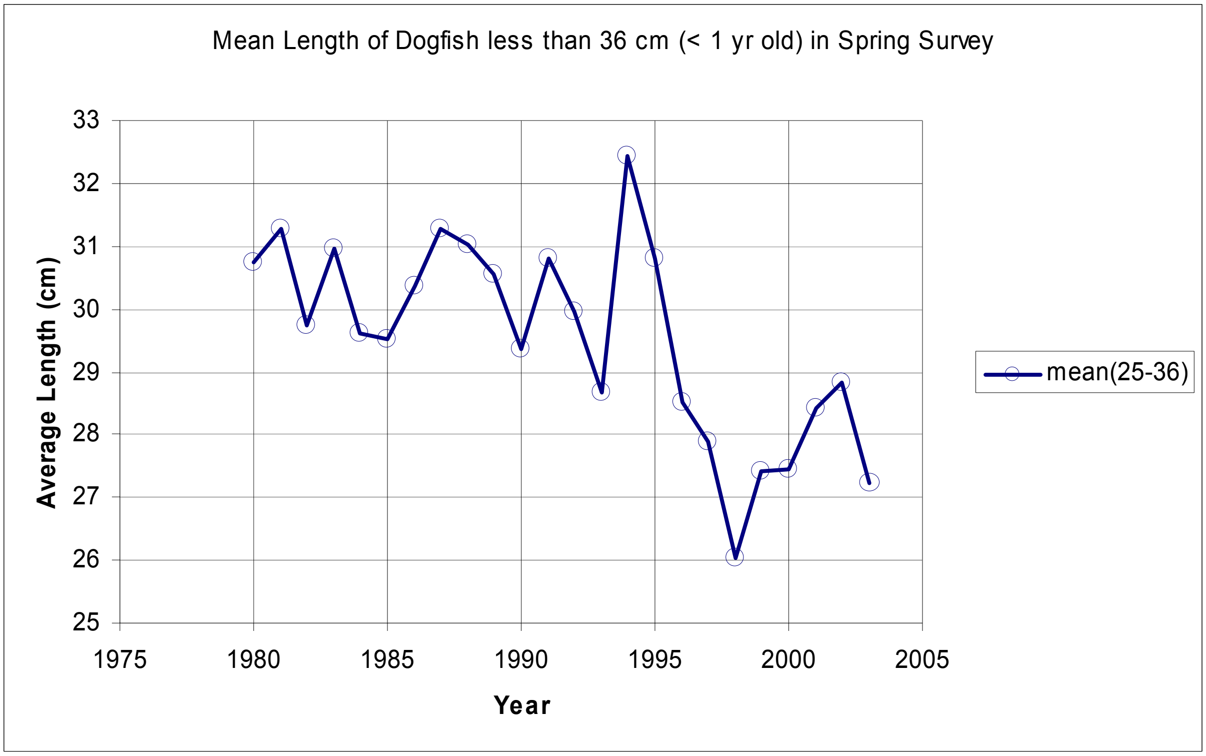
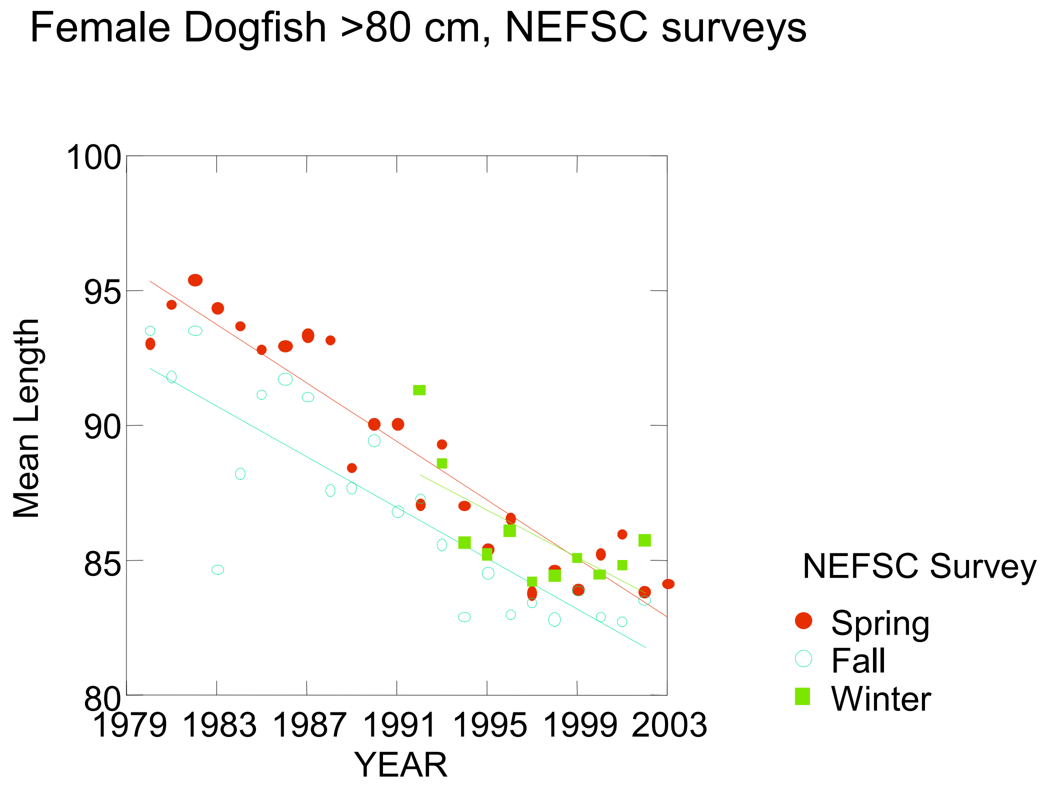


Fig. B6.6 Trend in average size of dogfish recruits, 1980-2003. Recruits defined as individuals less than 36 cm.



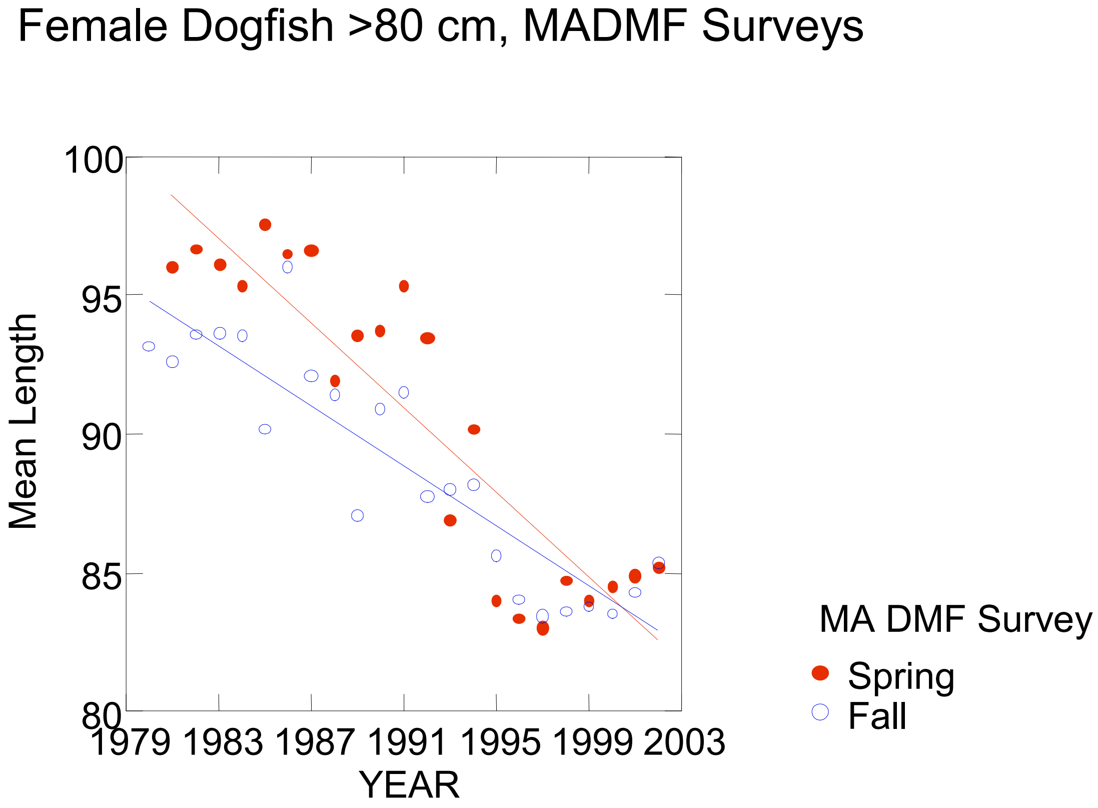


Fig. B6.7 Average size of mature female dogfish (>80cm) in NMFS R/V surveys, 1980-2003, (top) and MADMF R/V surveys (bottom), 1980-2002.

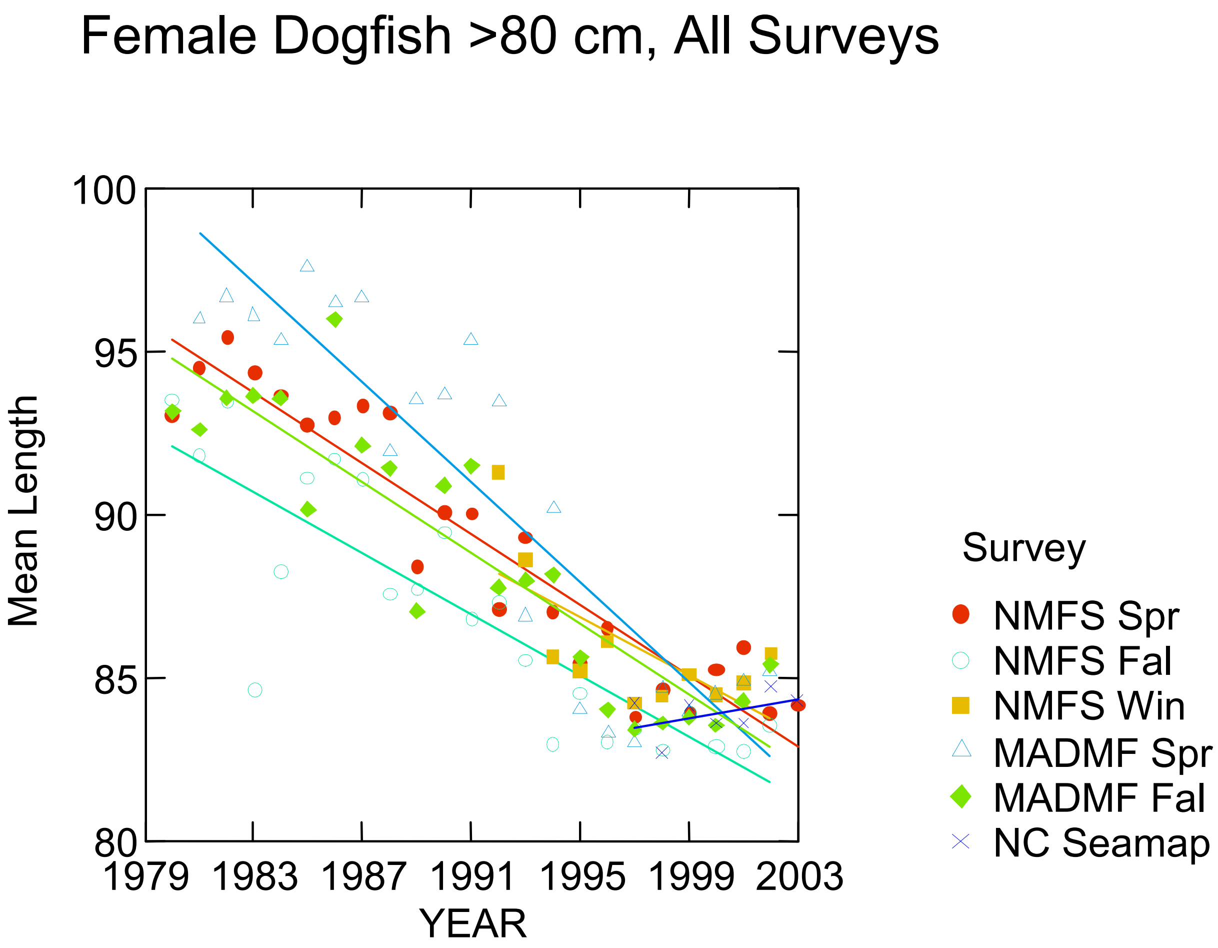
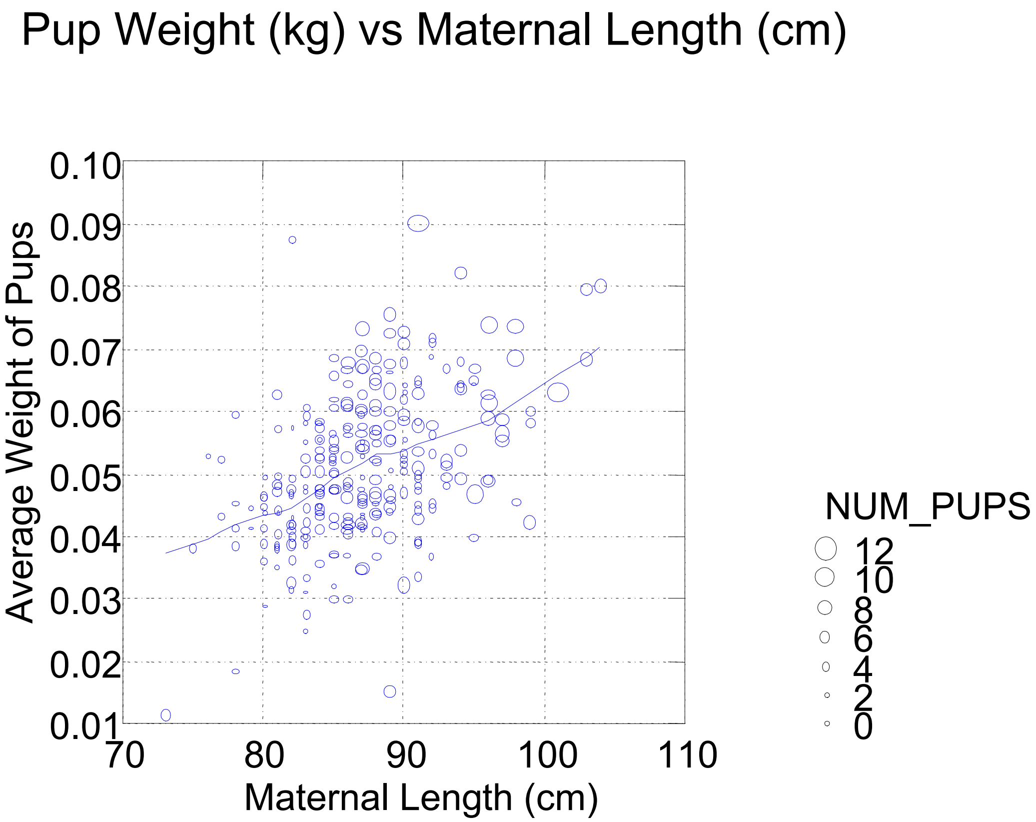


Fig. B6.8 Average size of mature female dogfish (>80cm) in all surveys: NMFS R/V surveys, 1980-2003, and MADMF R/V surveys, 1980-2002, and NC SeaMap survey.



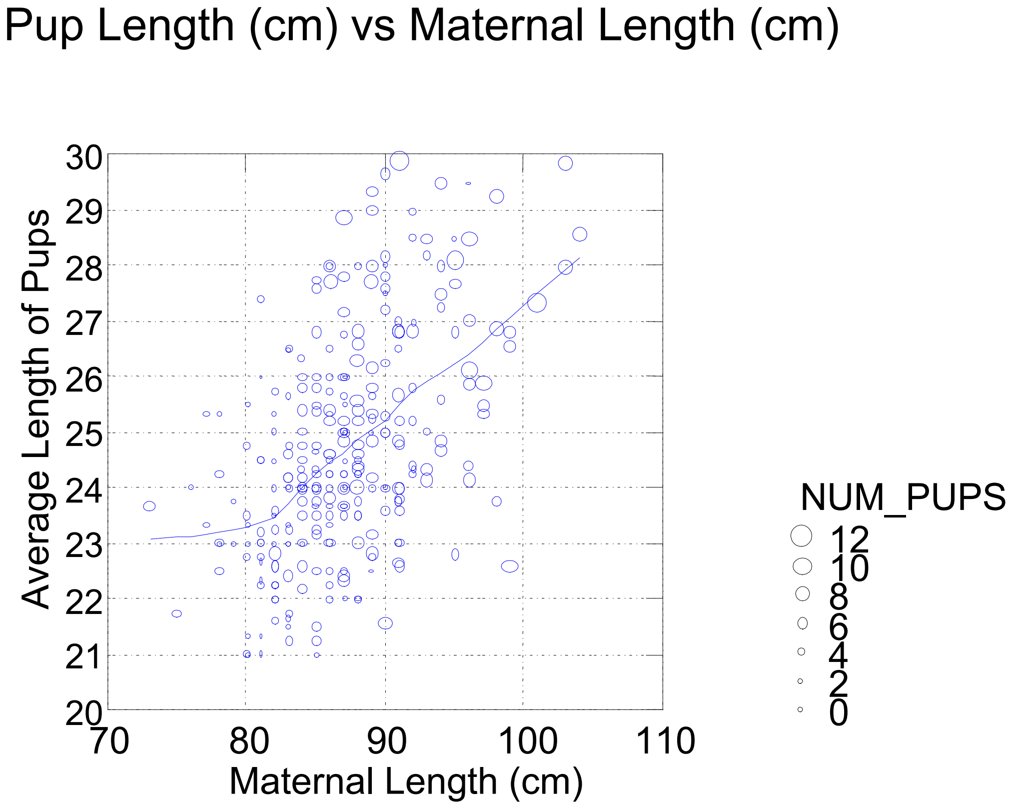


Fig. B6.9 Relationship between average weight (kg) of near-term pups (top) and average length (cm) of pups (bottom) with maternal length (cm). Circle size is proportional to number of pups in brood. Line represents Lowess smooth with tension =0.5.

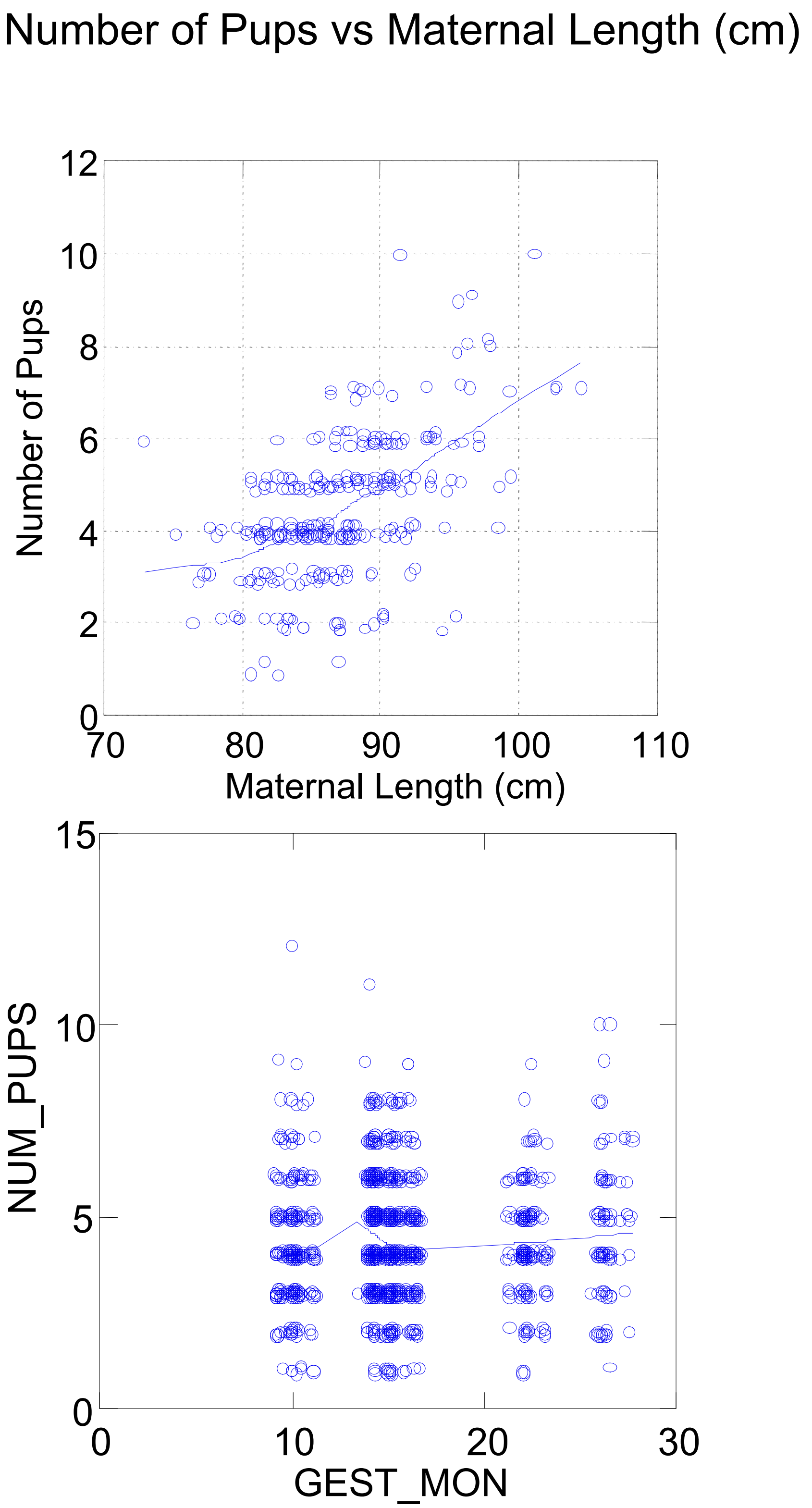


Fig. B6.10 Relationship between number of near-term pups per brood (top) and maternal length (cm). Bottom panel shows relationship between gestational month and number of pups present in brood. Lines represents Lowess smooth with tension =0.5.

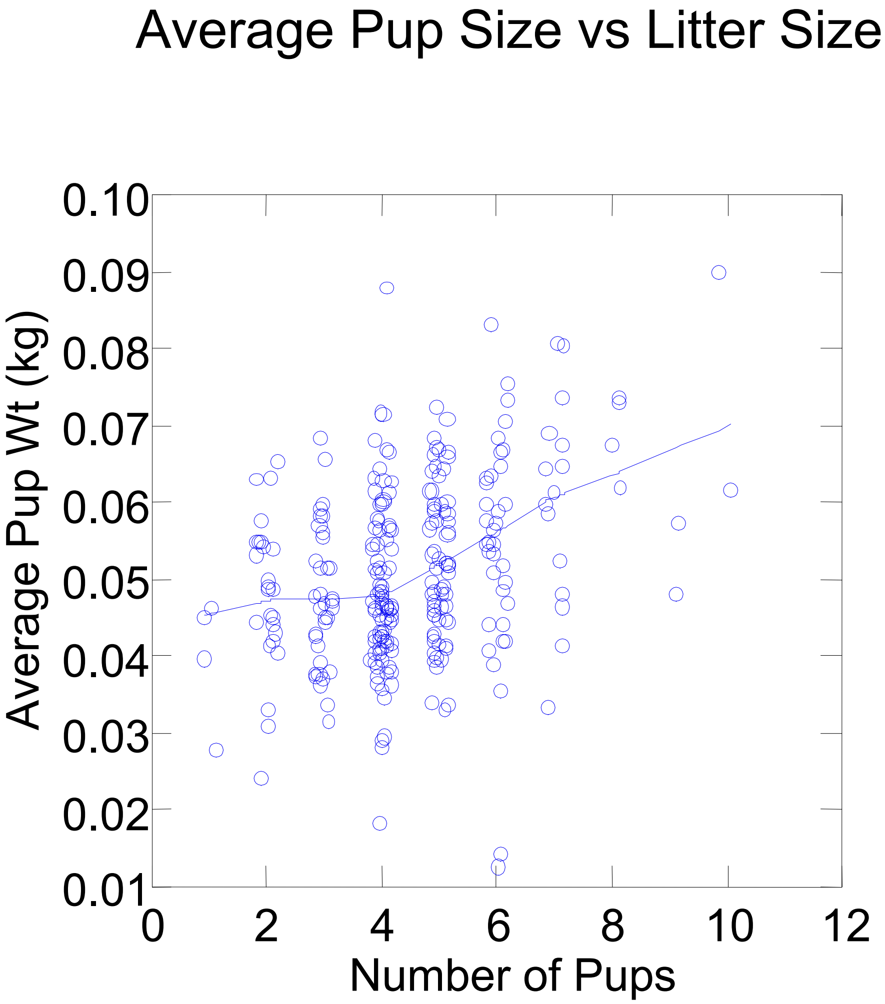


Fig. B6.11 Relationship between average size of near term free embryos and number of pups present in brood, based on 1998-2002 samples. Data points are jittered to show number of points within integer number of pups within brood. Line represent Lowess smooth with tension =0.5.

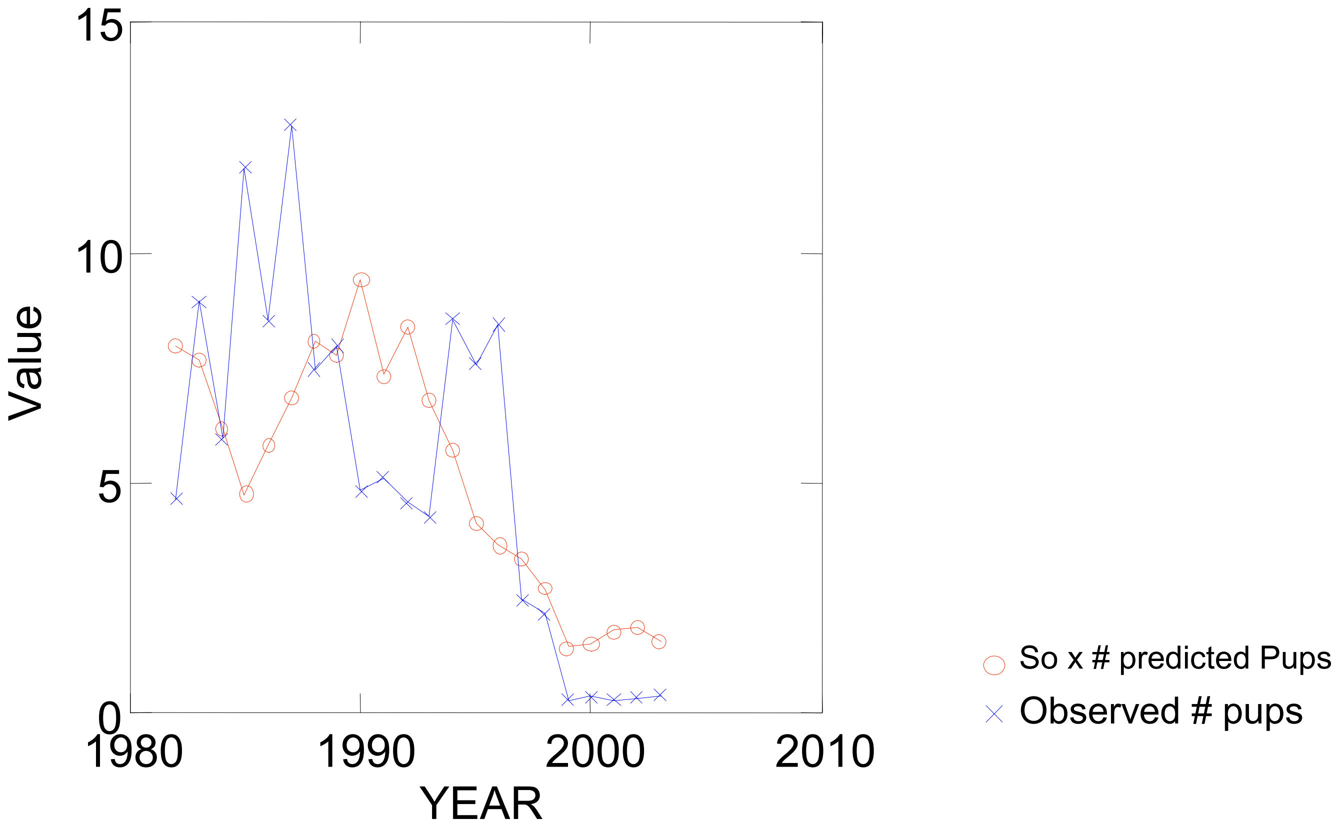


Fig. B6.12 Comparison of observed and predicted number of pups based on a 3 yr moving average. Predicted pups estimated as sum product of abundance and number per tow, multiplied by first year survival rate estimated from life history model. Observed number of pups is total number per tow in the <36 cm range. No adjustments for scale have been made.

Num Spawners/Tow (lf) and Maternal Size (rt) vs year

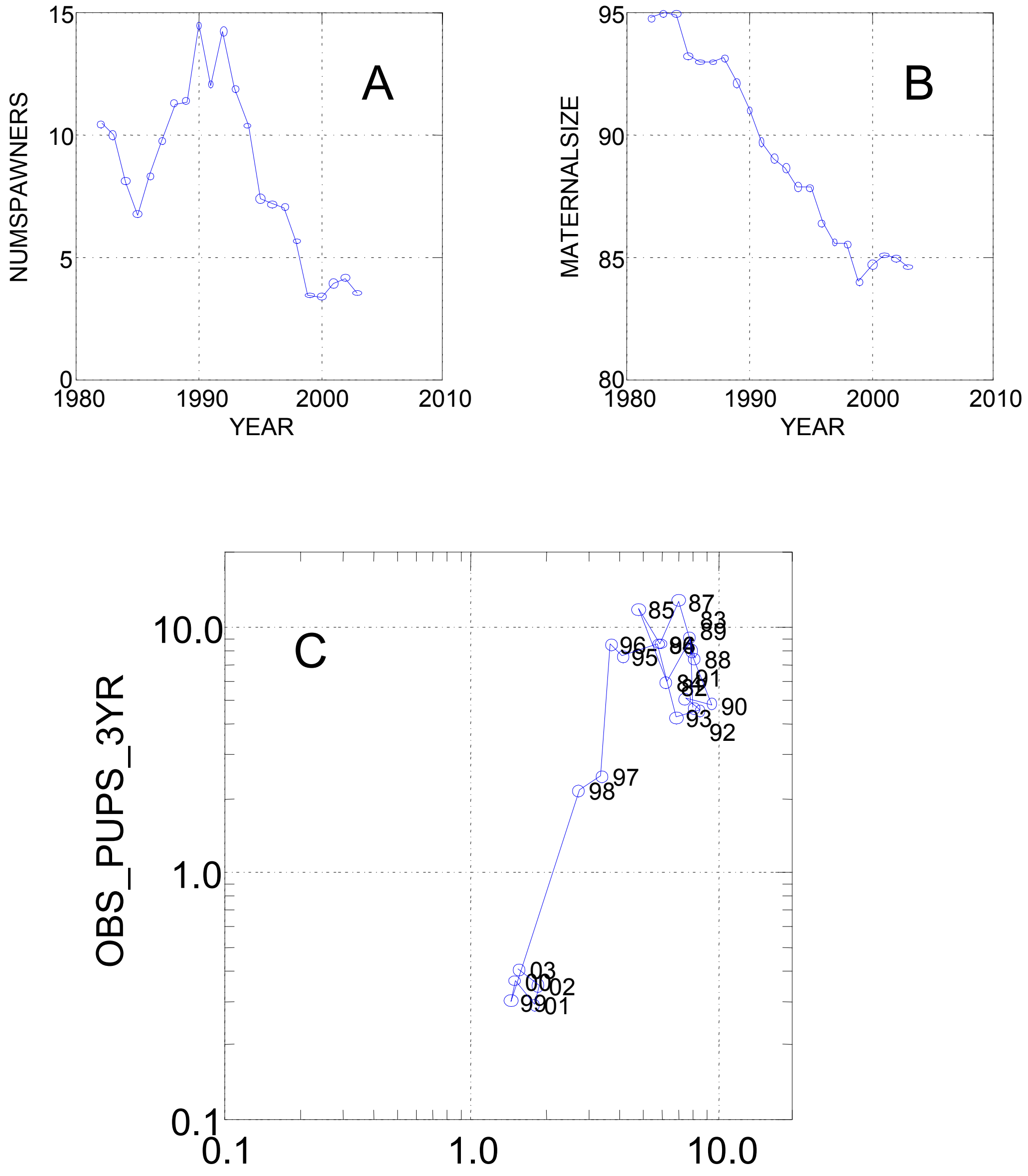


Fig. B6.13. Summary of trends in total number of mature female dogfish (#/tow) (A), average maternal size (cm) (B) and relationship between observed and predicted numbers of pups C.

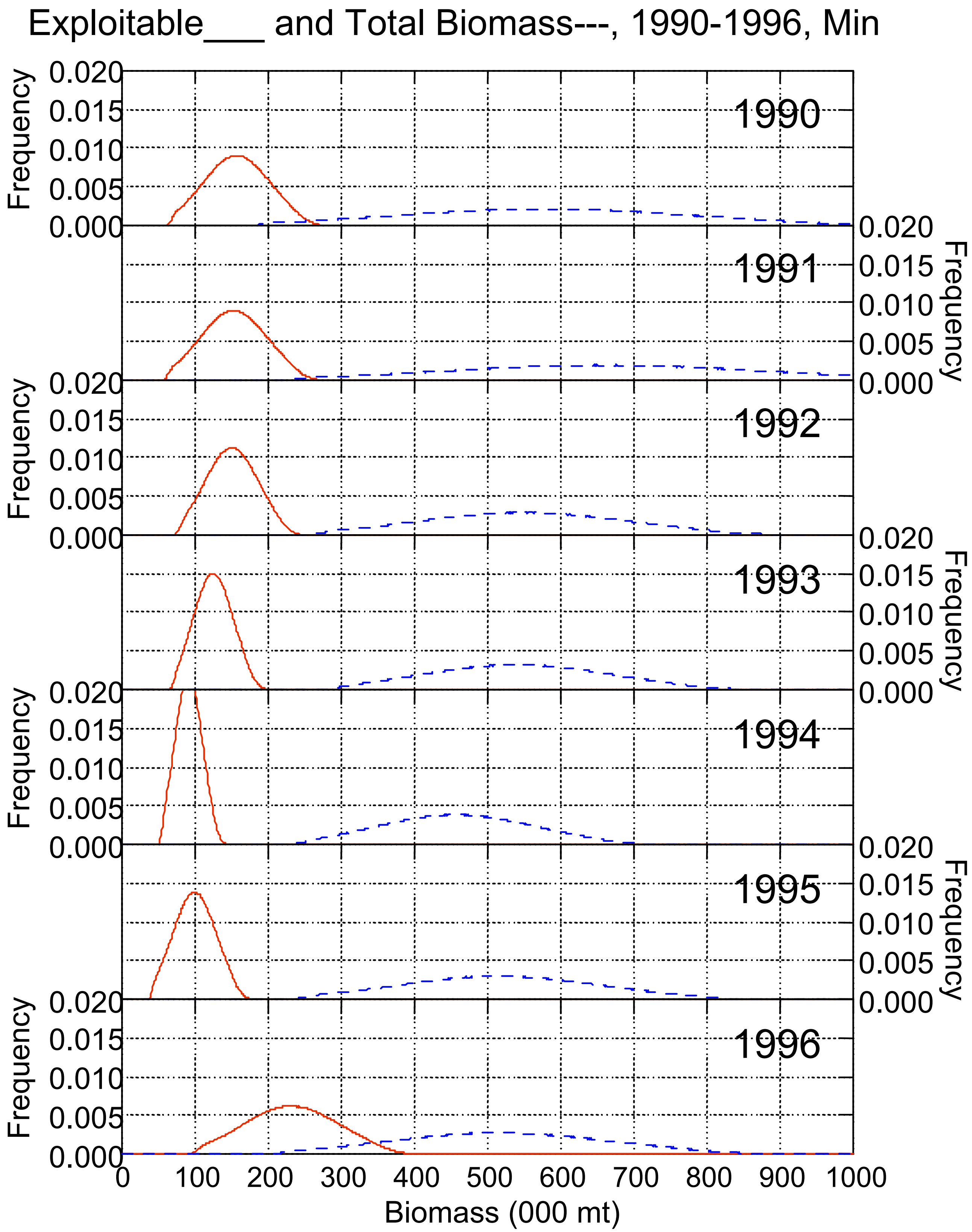


Fig. B7.3 a. Sampling distribution of exploitable(solid line) and total biomass (dashed line) of spiny dogfish, 1990-1996, under the assumption of the minimum trawl footprint.

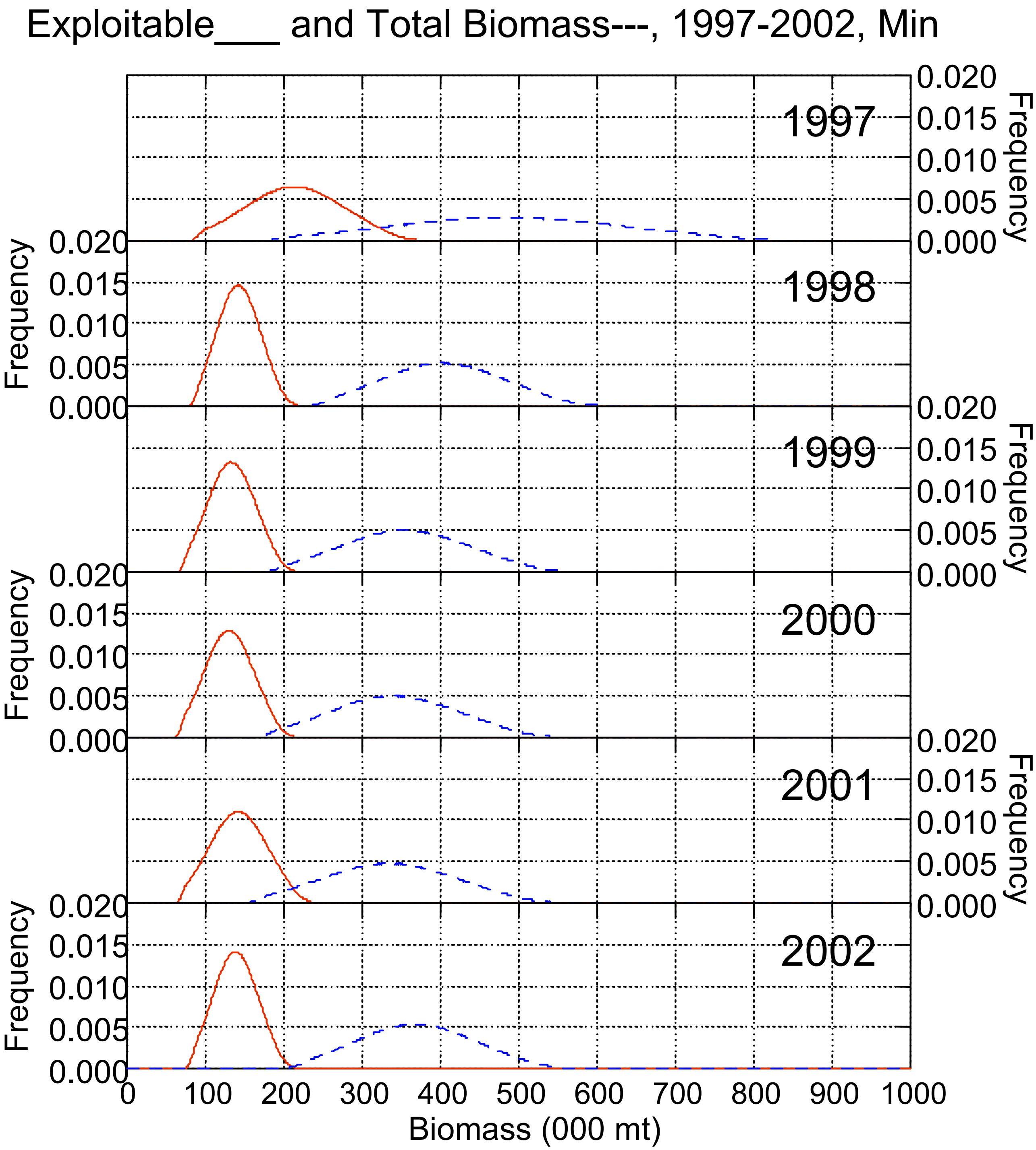


Fig. B7.3 b. Sampling distribution of exploitable(solid line) and total biomass (dashed line) of spiny dogfish, 1997-2002, under the assumption of the maximum trawl footprint.

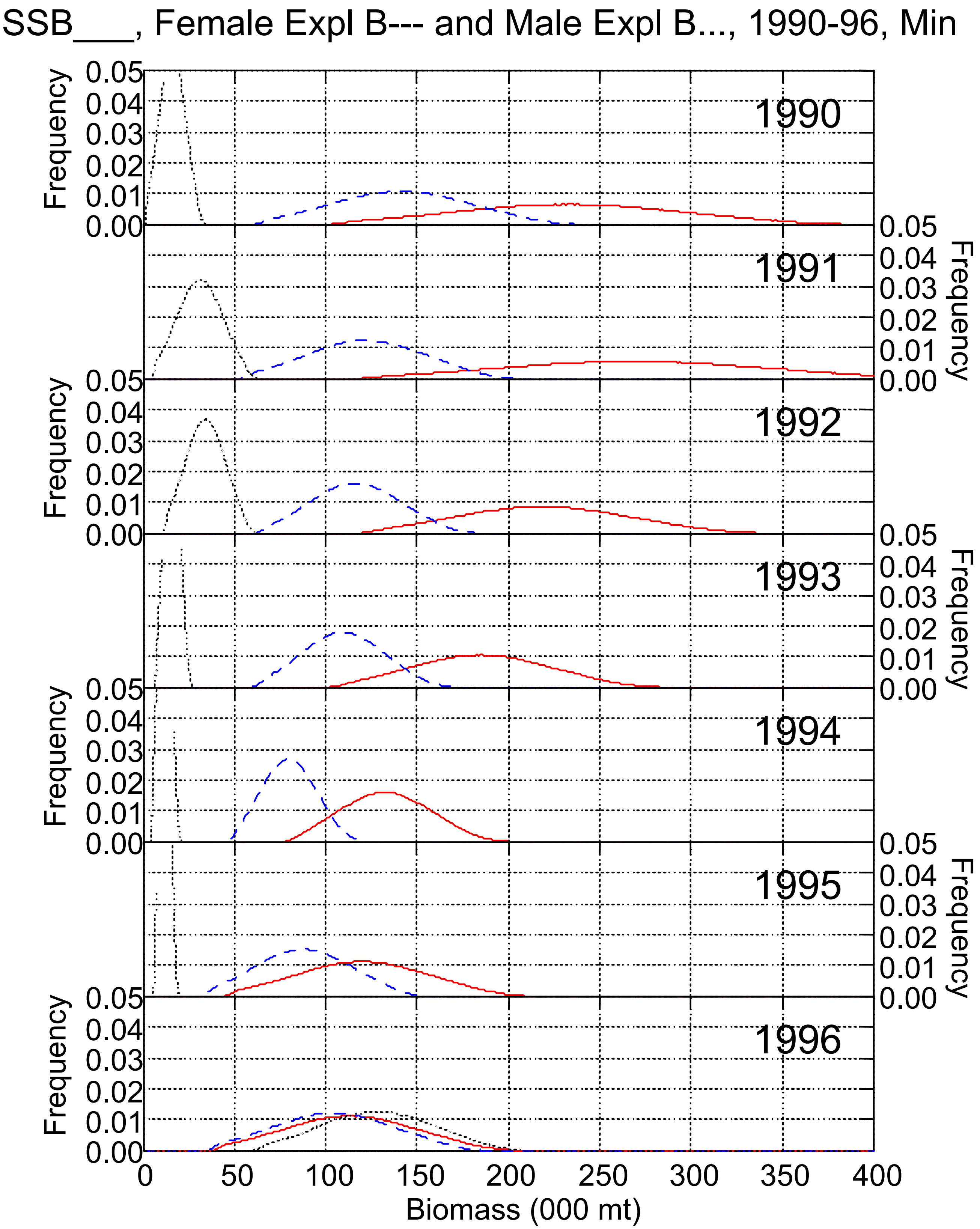


Fig. B7.4 a. Sampling distribution of spawning stock biomass (solid line), female exploitable biomass (dashed) and male exploitable biomass (dashed line) of spiny dogfish, 1990-1996, under the assumption of the minimum trawl footprint.

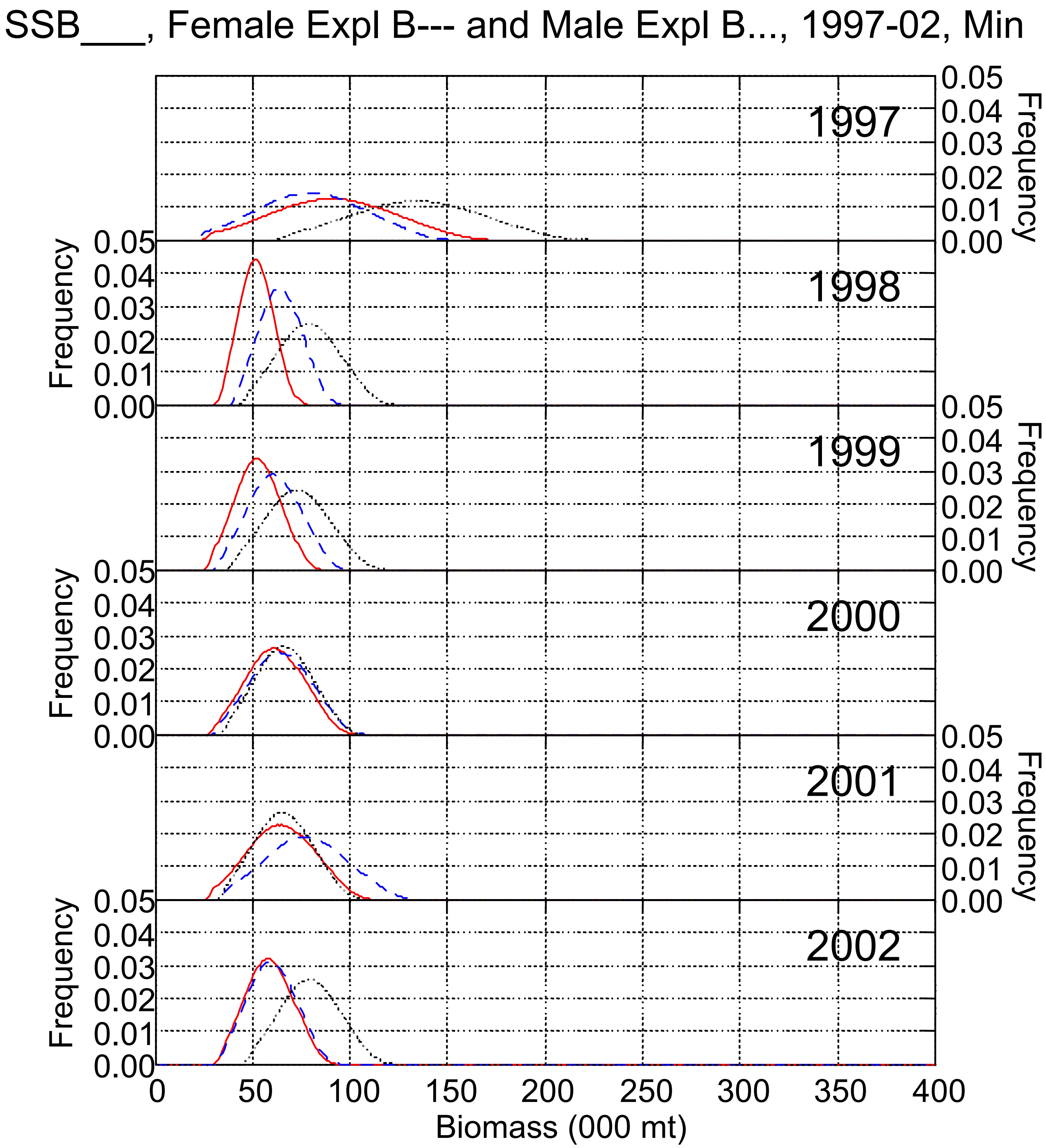


Fig. B7.4 b. Sampling distribution of spawning stock biomass (solid line), female exploitable biomass (dashed) and male exploitable biomass (dashed line) of spiny dogfish, 1997-2002, under the assumption of the minimum trawl footprint.

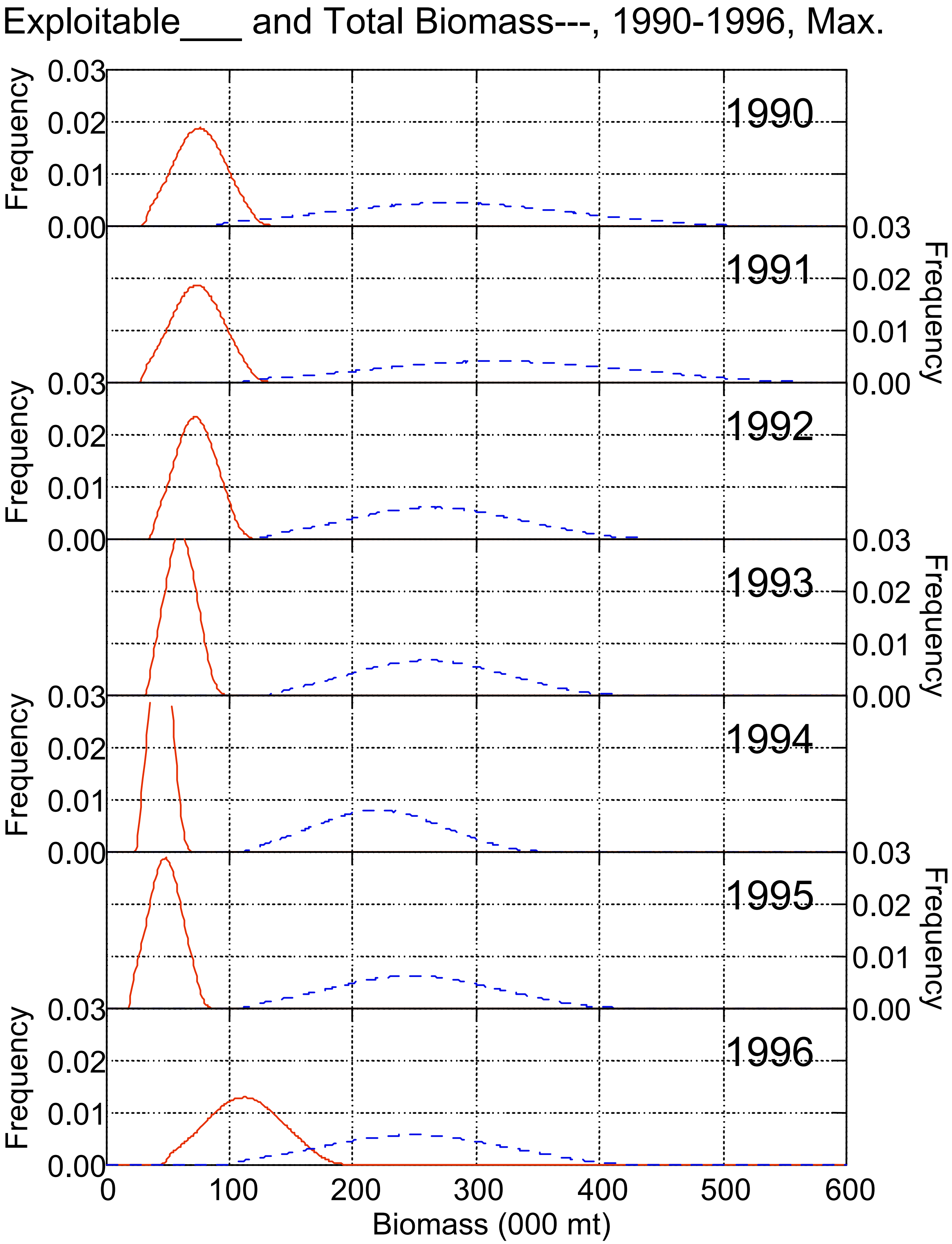


Fig. B7.5 a. Sampling distribution of exploitable(solid line) and total biomass (dashed line) of spiny dogfish, 1990-1996, under the assumption of the maximum trawl footprint.

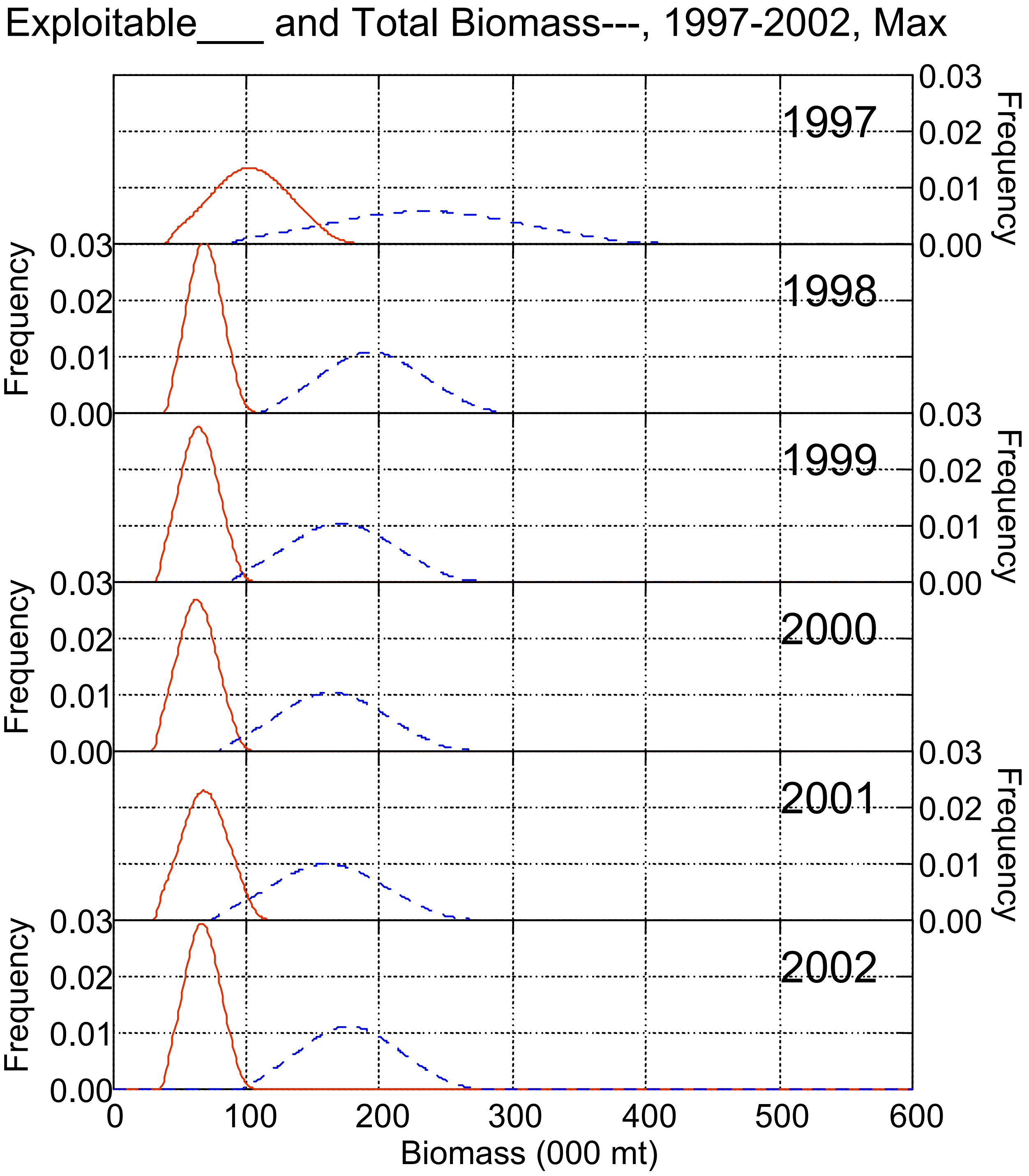


Fig. B7.5 b. Sampling distribution of exploitable(solid line) and total biomass (dashed line) of spiny dogfish, 1997-2002, under the assumption of the maximum trawl footprint.

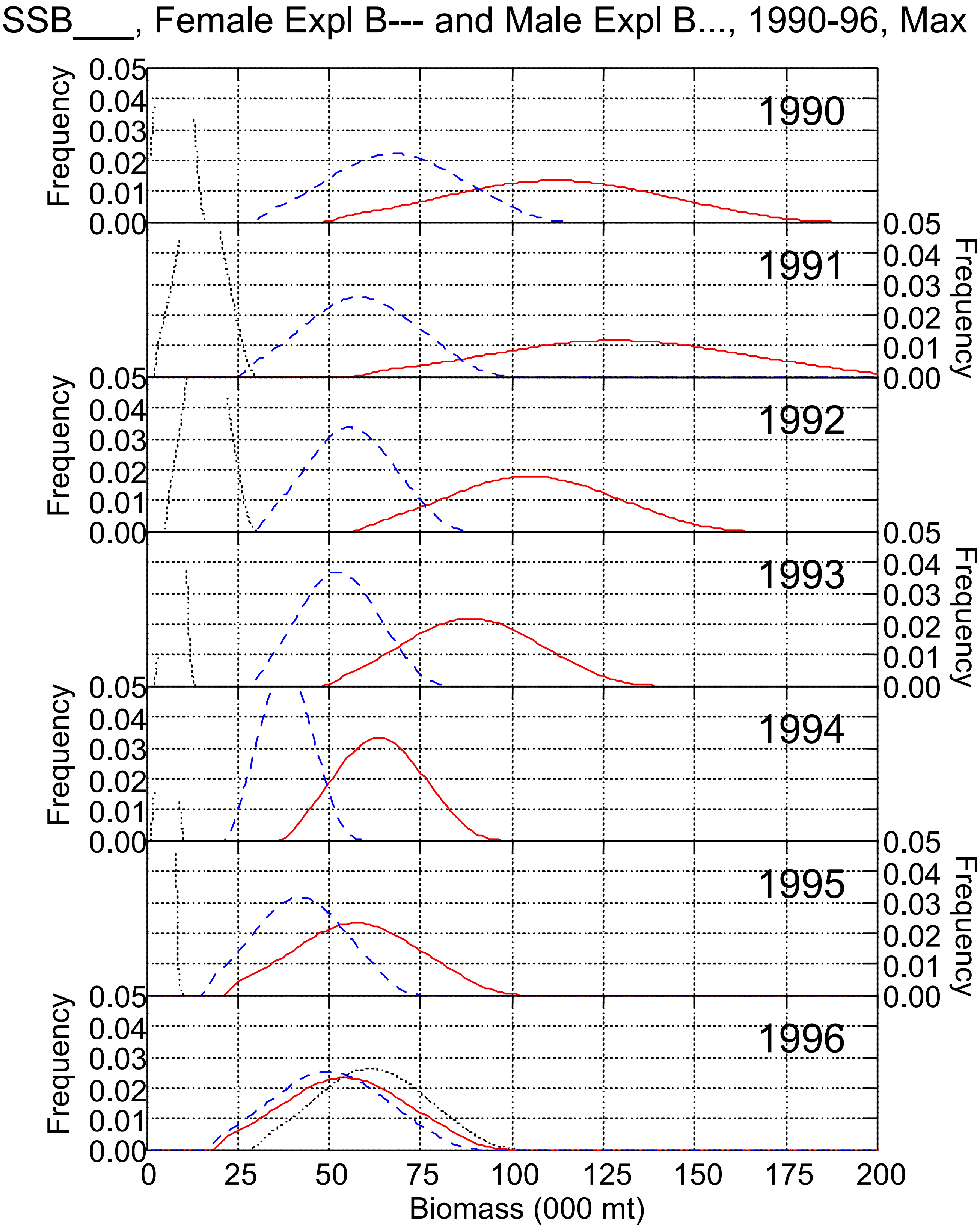


Fig. B7.6 a. Sampling distribution of spawning stock biomass (solid line), female exploitable biomass (dashed) and male exploitable biomass (dashed line) of spiny dogfish, 1990-1996, under the assumption of the maximum trawl footprint.

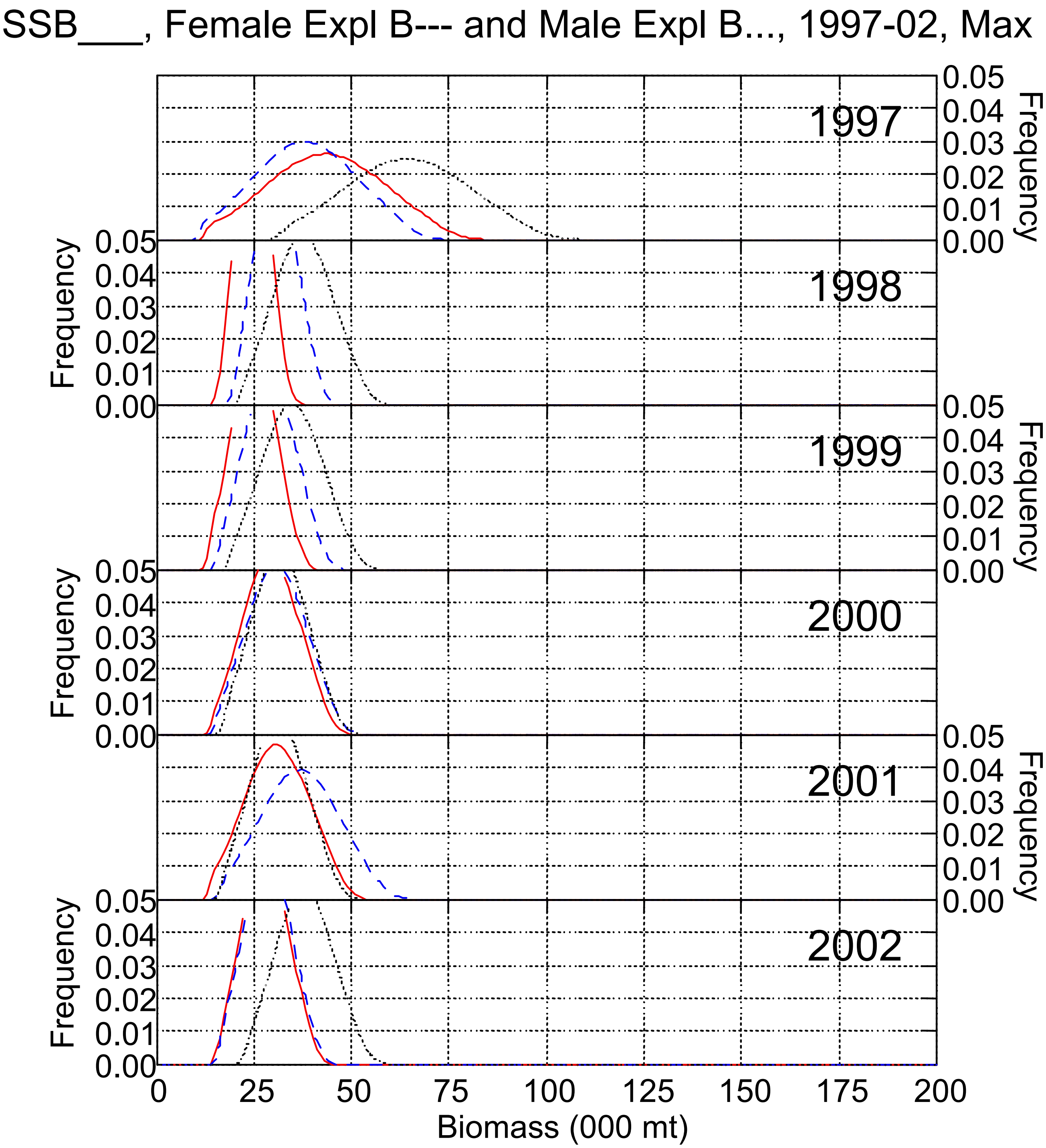


Fig. B7.6b. Sampling distribution of spawning stock biomass (solid line), female exploitable biomass (dashed) and male exploitable biomass (dashed line) of spiny dogfish, 1997-2002, under the assumption of the maximum trawl footprint.

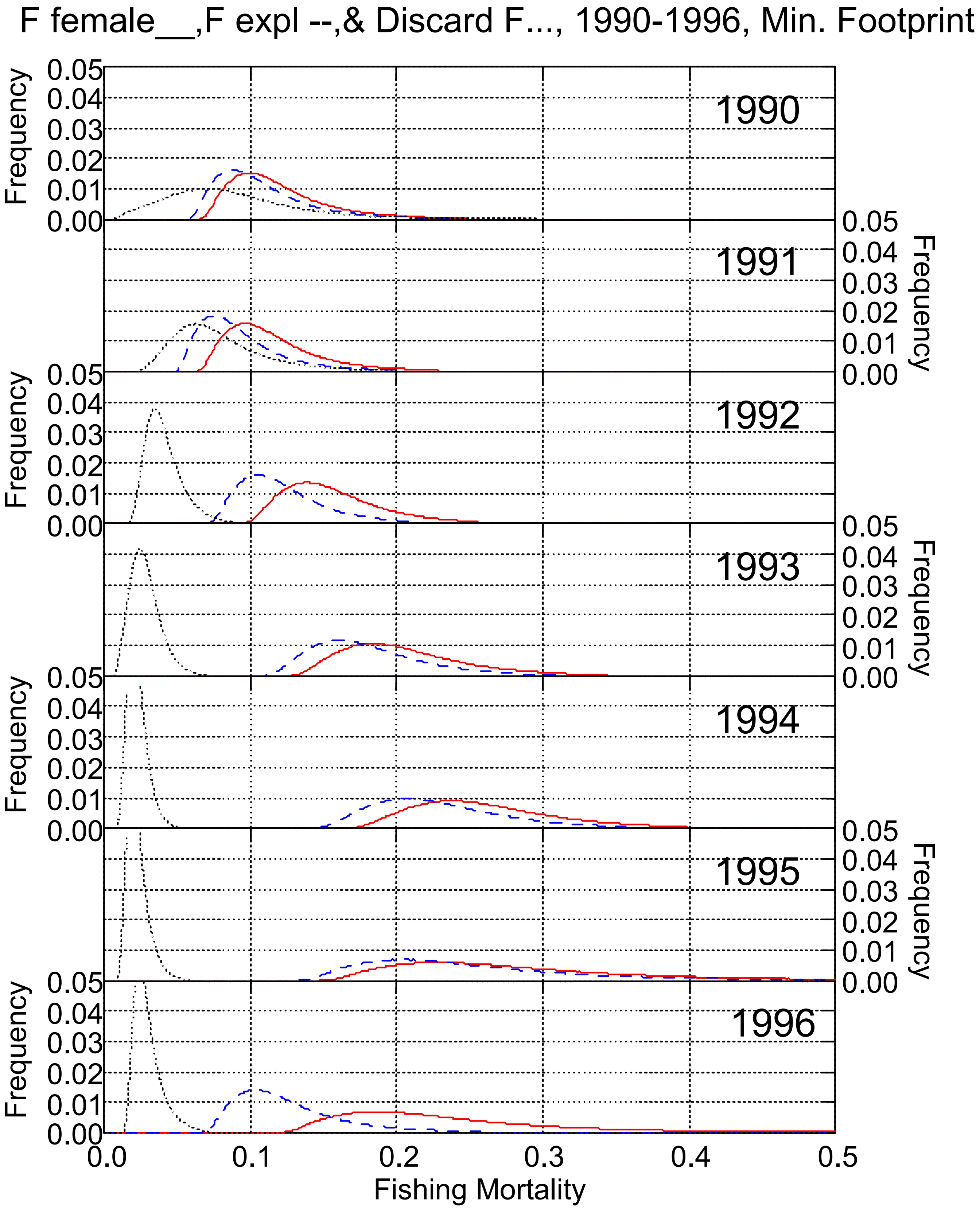


Fig. B7.7 a. Sampling distribution of fishing mortality on female exploitable biomass (solid line), on total exploitable biomass (dashed) and fishing mortality from discards on total biomass (dots) of spiny dogfish, 1990-1996, under the assumption of the minimum trawl footprint.

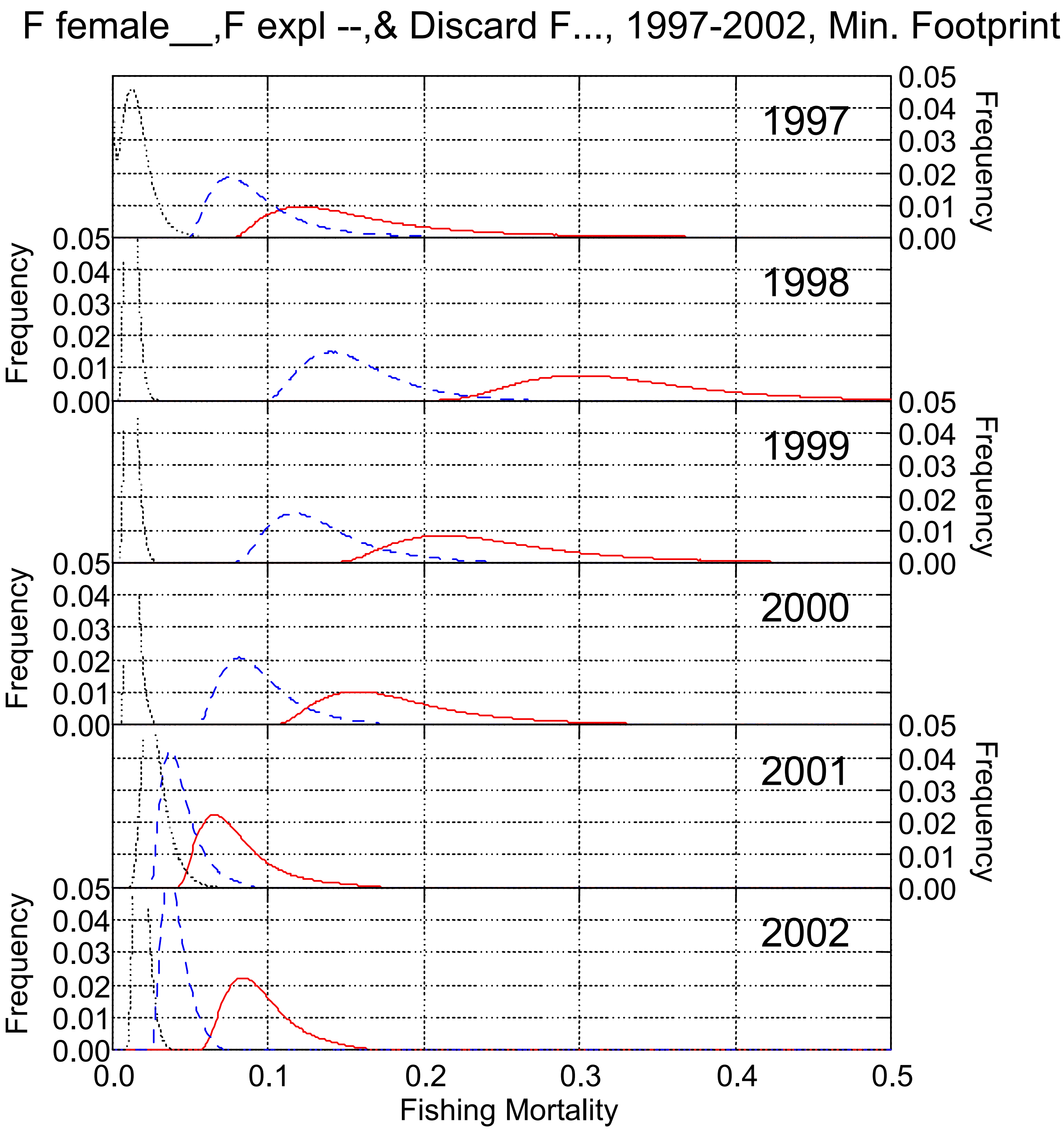


Fig. B7.7 b. Sampling distribution of fishing mortality on female exploitable biomass (solid line), on total exploitable biomass (dashed) and fishing mortality from discards on total biomass (dots) of spiny dogfish, 1997-2002, under the assumption of the minimum trawl footprint.

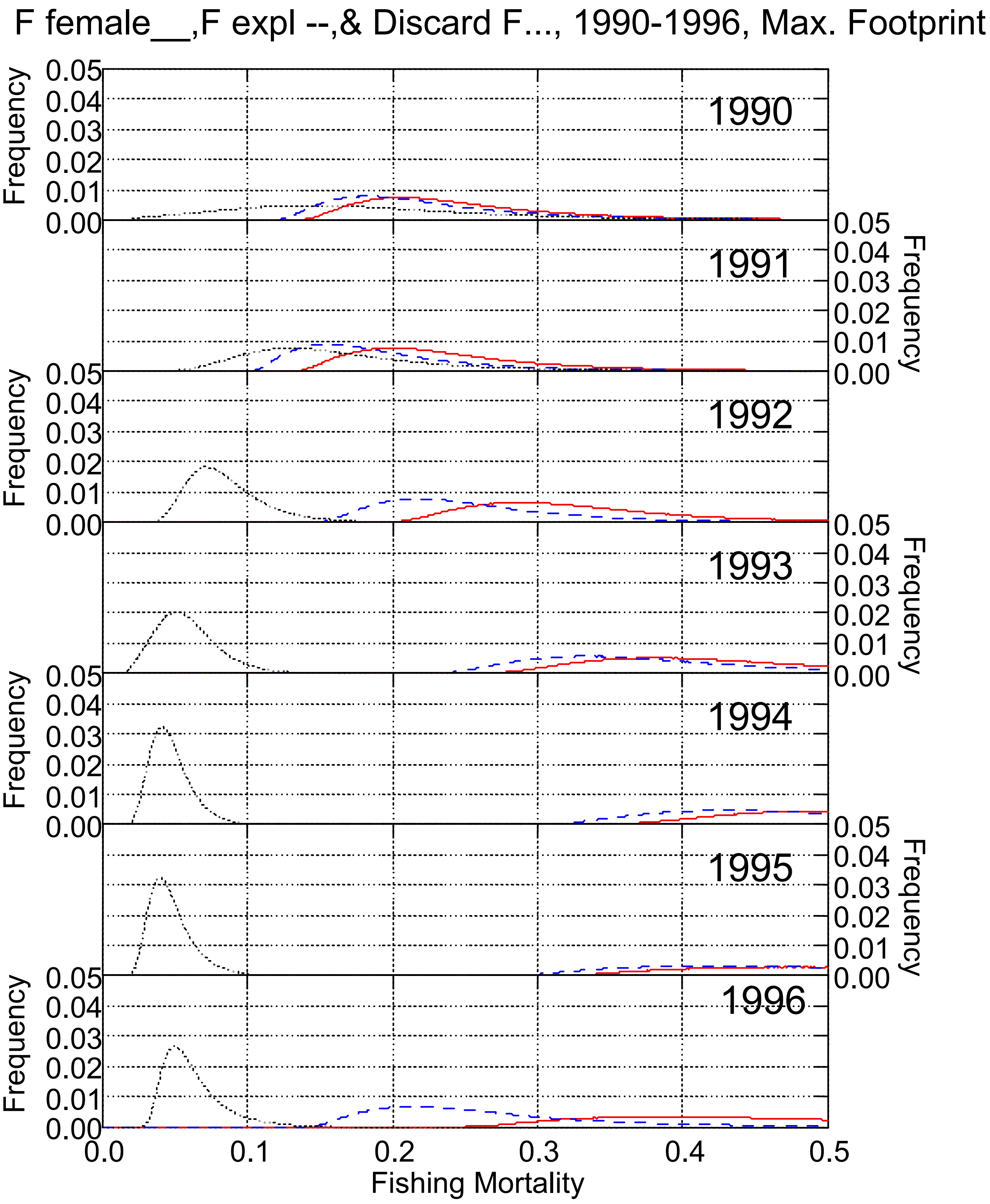


Fig. B7.8 a. Sampling distribution of fishing mortality on female exploitable biomass (solid line), on total exploitable biomass (dashed) and fishing mortality from discards on total biomass (dots) of spiny dogfish, 1990-1996, under the assumption of the maximum trawl footprint.

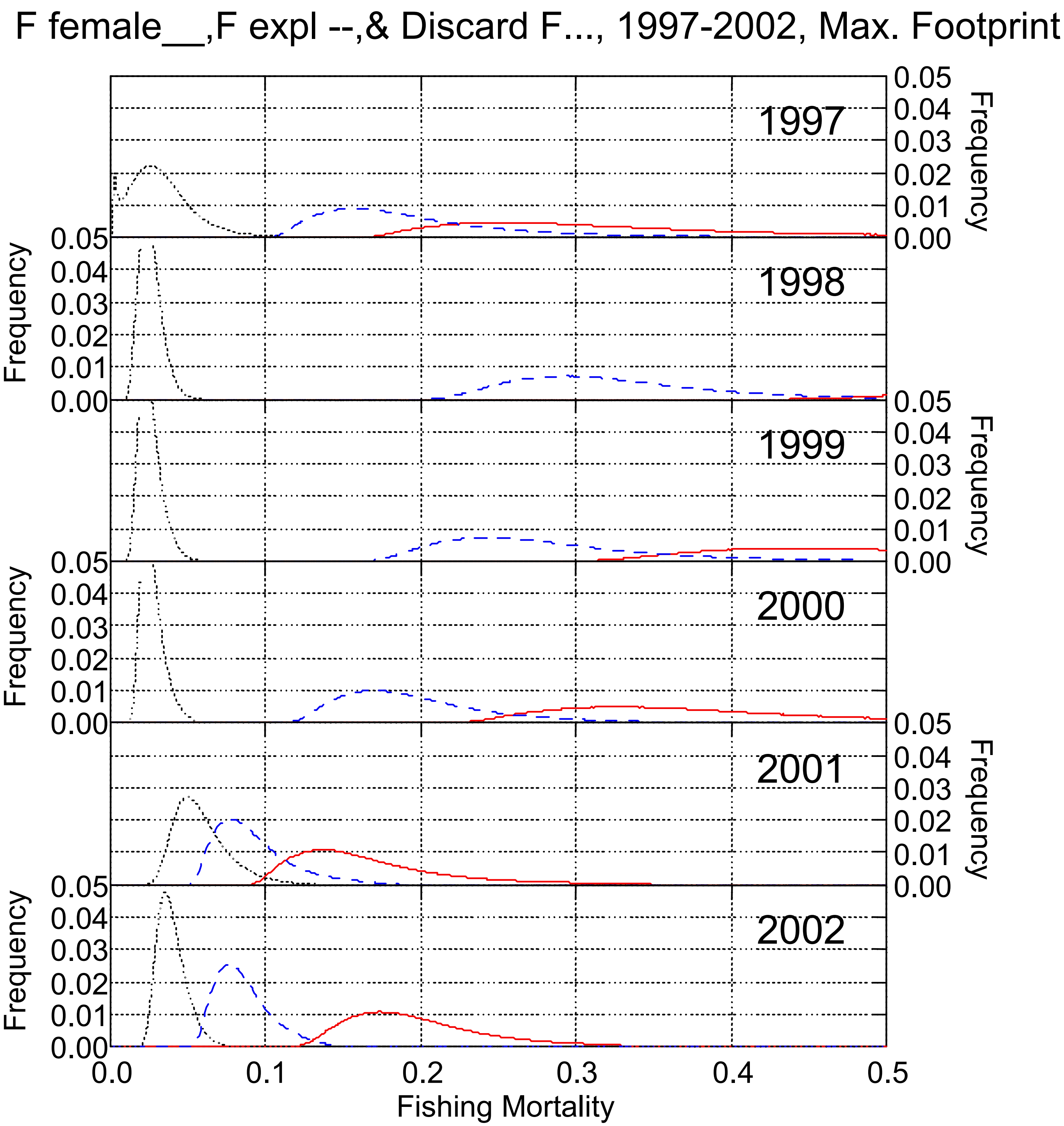


Fig. B7.8 b. Sampling distribution of fishing mortality on female exploitable biomass (solid line), on total exploitable biomass (dashed) and fishing mortality from discards on total biomass (dots) of spiny dogfish, 1997-2002, under the assumption of the maximum trawl footprint.

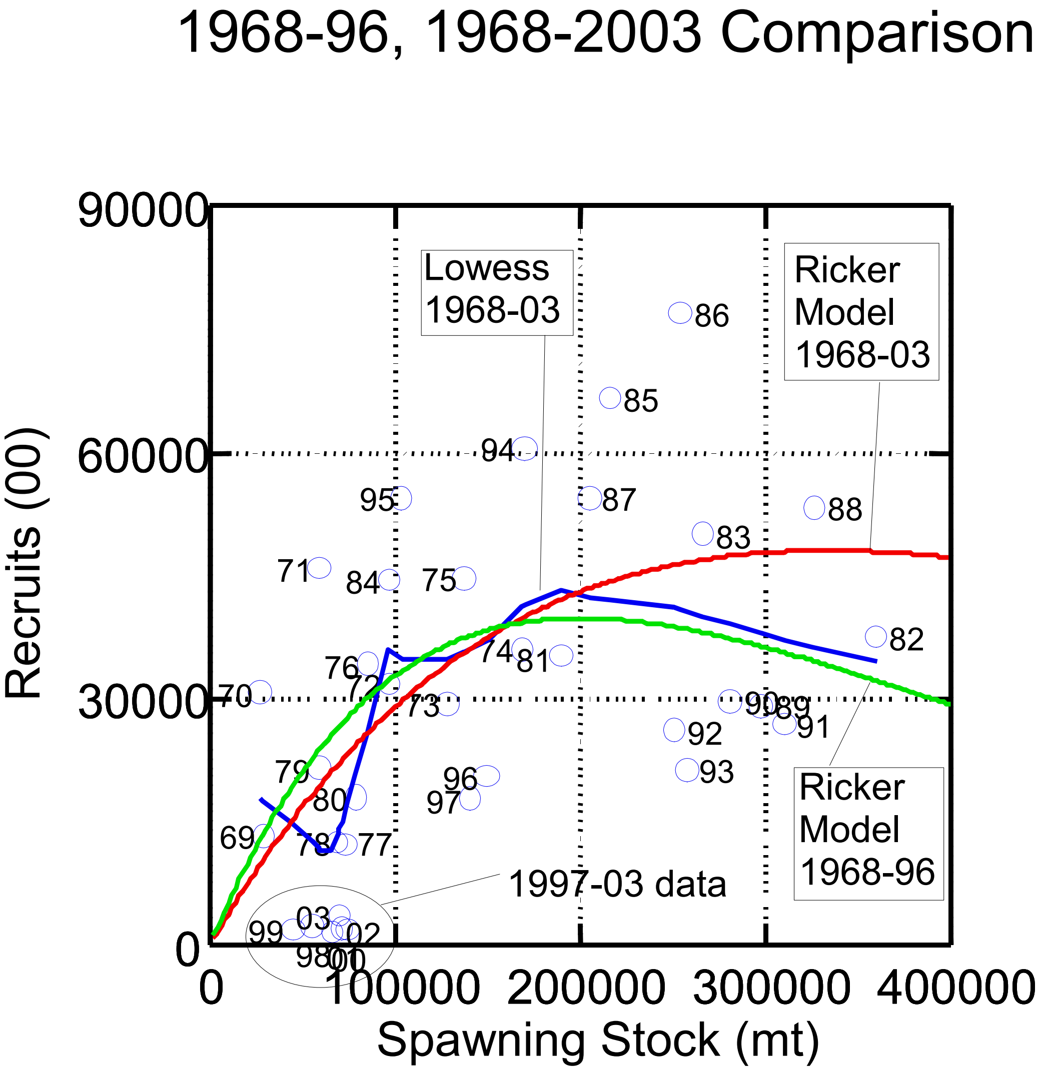


Figure B8.1 Comparison of parametric and nonparametric S-R curves for spiny dogfish for 1968-1996 (top), 1968-2003 (bottom). Point estimates of SSB_{max} based on nominal footprint of 0.01 nm^2 and unscaled NEFSC spring trawl survey catch rates. Nonparametric models based on Lowess smooths with tension = 0.6, suggest no change in SSBmax estimates. Biomass corresponding to 0.01 nm^2 footprint is 215 k mt. This corresponds to a NEFSC Spring Survey average catch of 33.2 kg/tow. Using the Ricker model for 1968-03 inflates the SSB_{max} to 294 k mt (45.2 kg/tow), owing to the low recruitment between 1997-03.

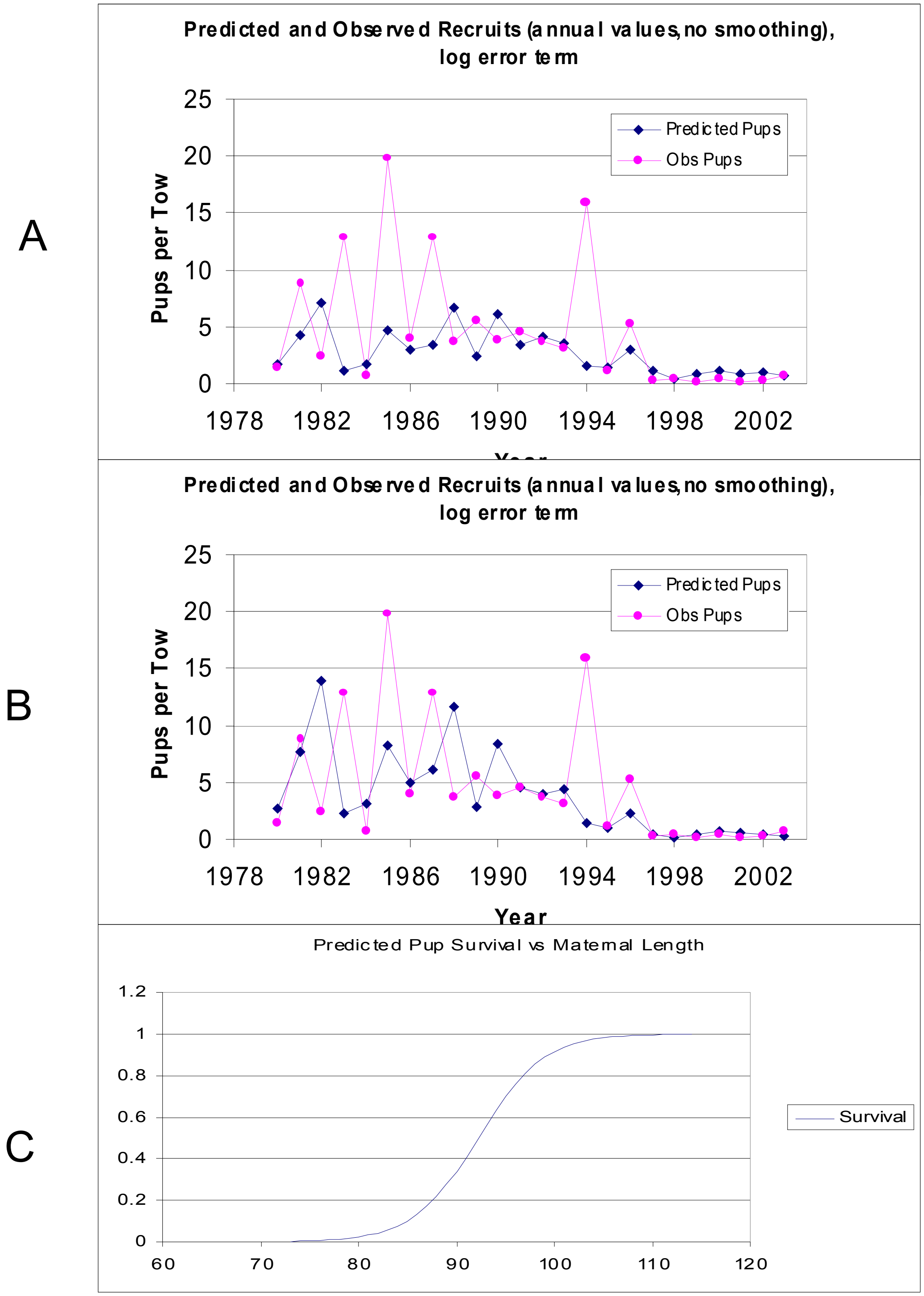


Fig. B8.2. Comparison of observed and predicted numbers of pups for two alternative demographic models. A Constant first year survival, with no maternal effect. B. First year survival increases with maternal size. The empirical estimate of first year survival vs maternal size is depicted in panel C.

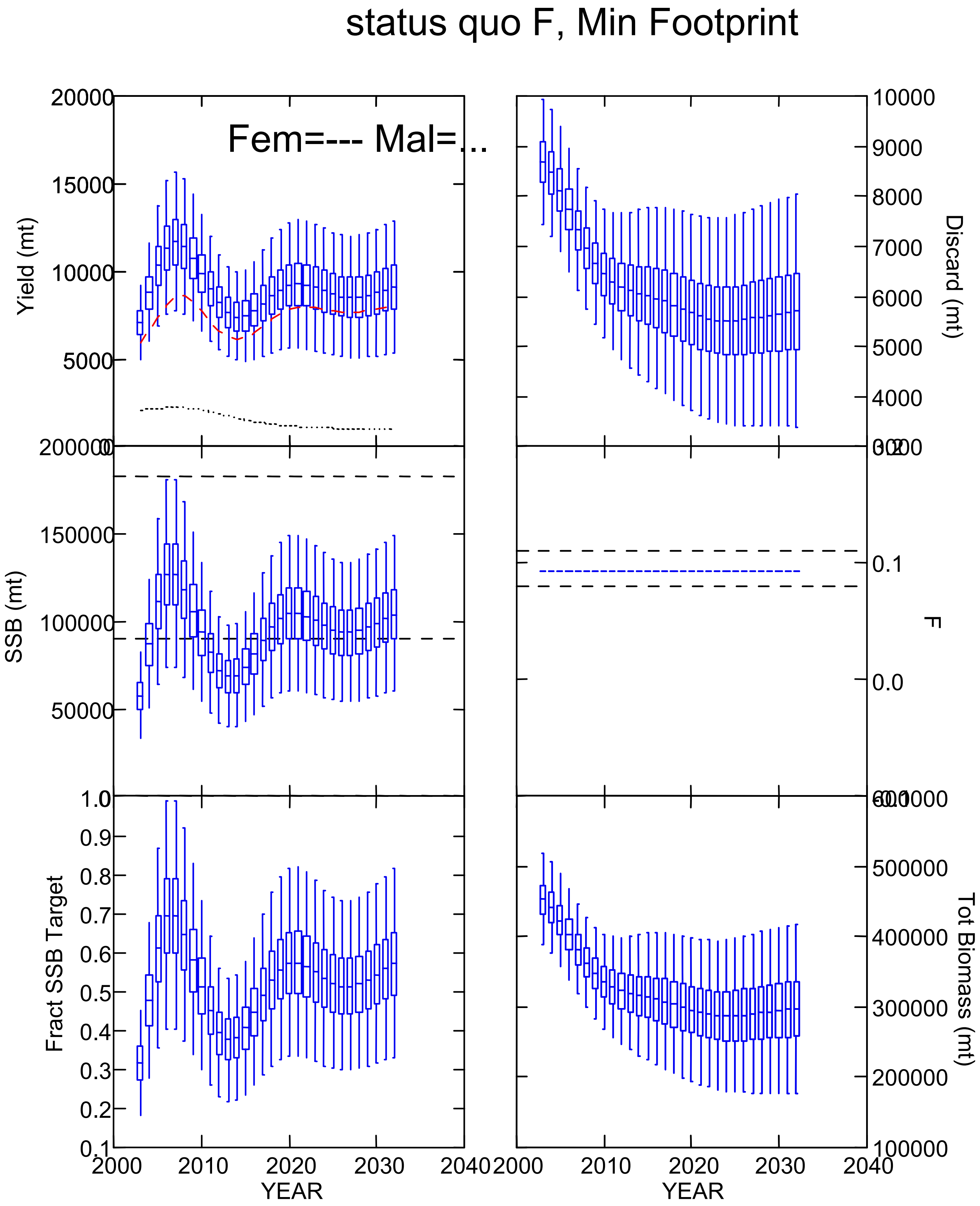


Fig. B9.1 Summary of projection model simulation results under the status quo F scenario. Minimum footprint is assumed. See text for details.

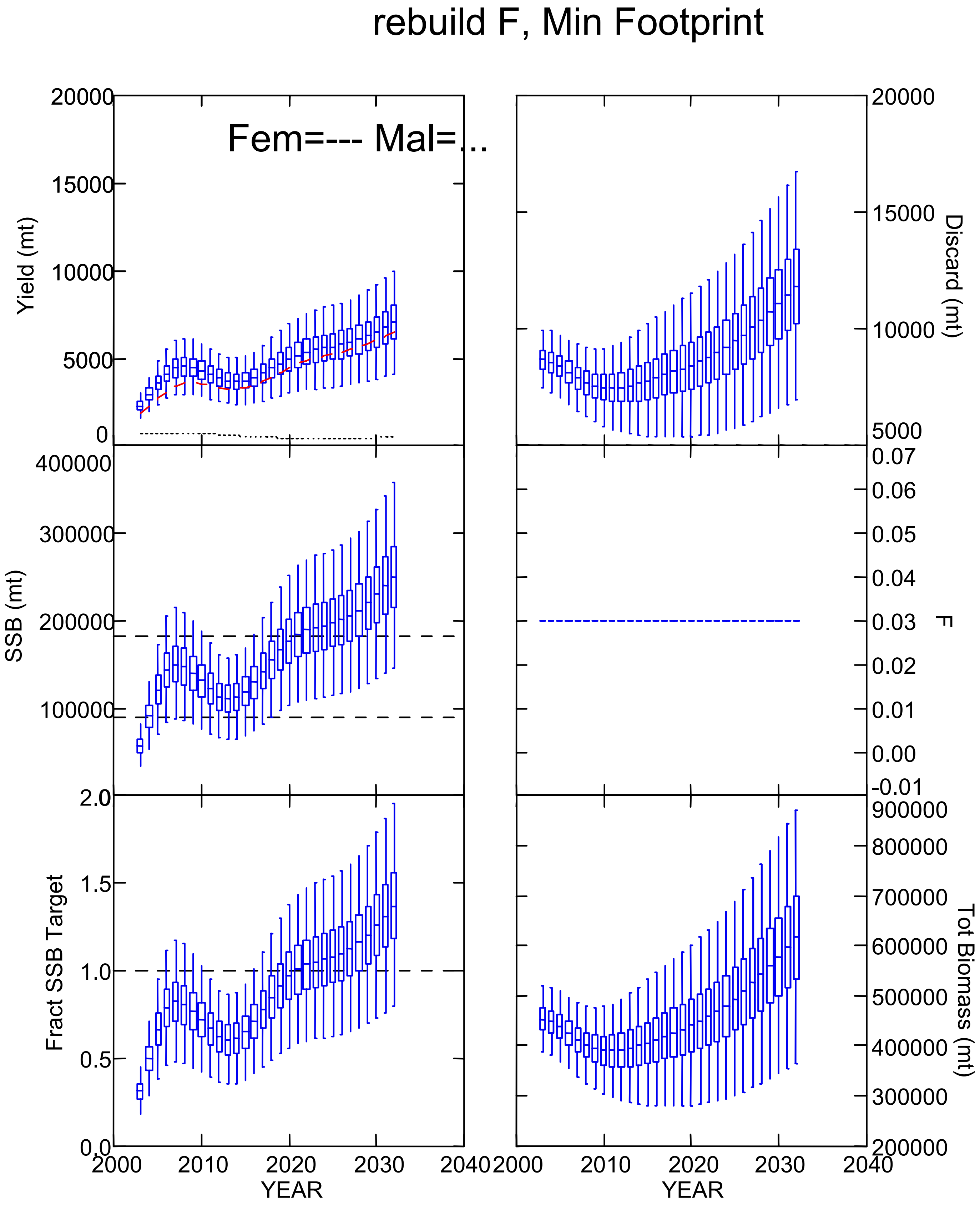


Fig. B9.2 Summary of projection model simulation results under the rebuild F scenario. Minimum footprint is assumed. See text for details.

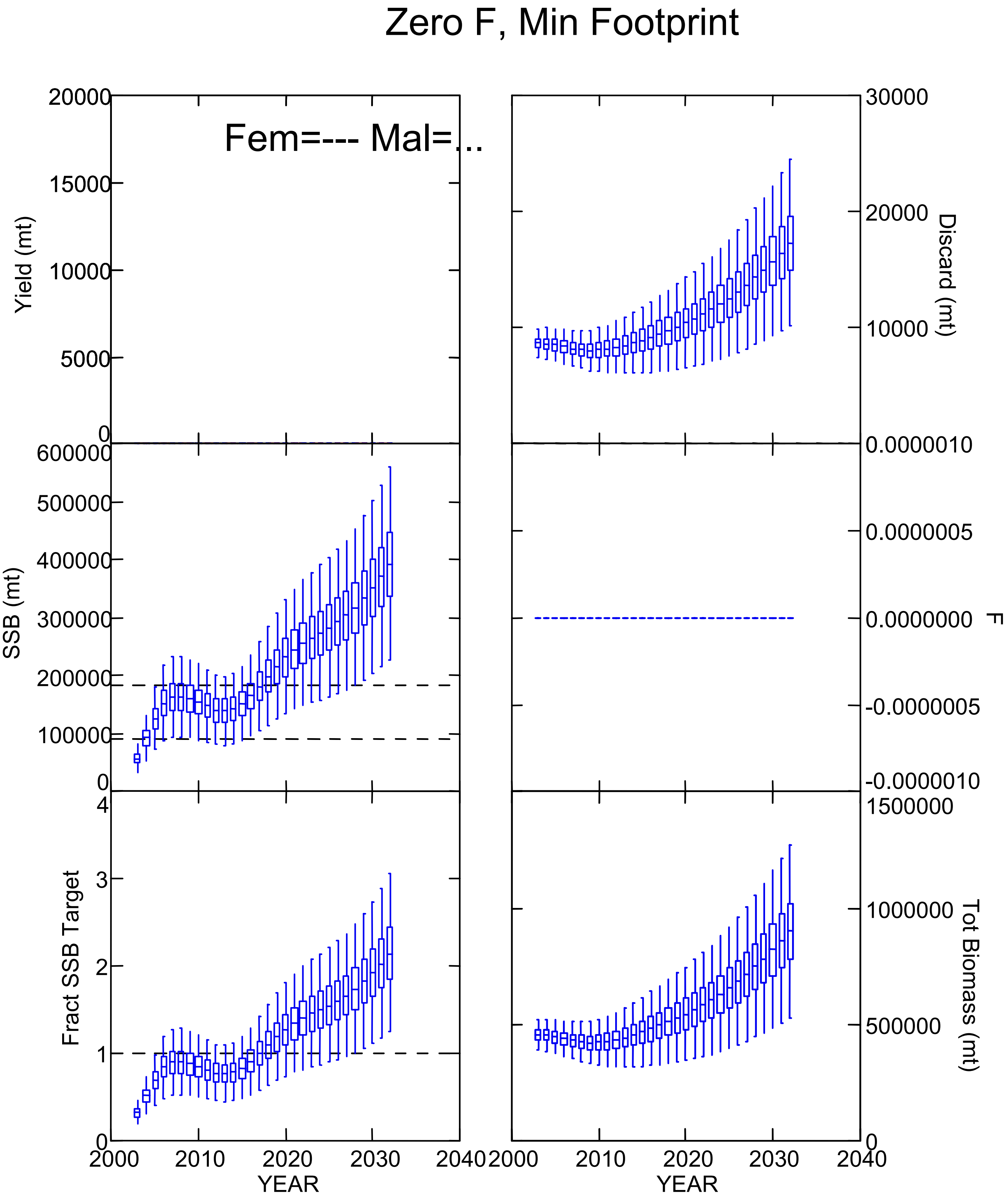


Fig. B9.3 Summary of projection model simulation results under the Zero F scenario. Minimum footprint is assumed. See text for details.

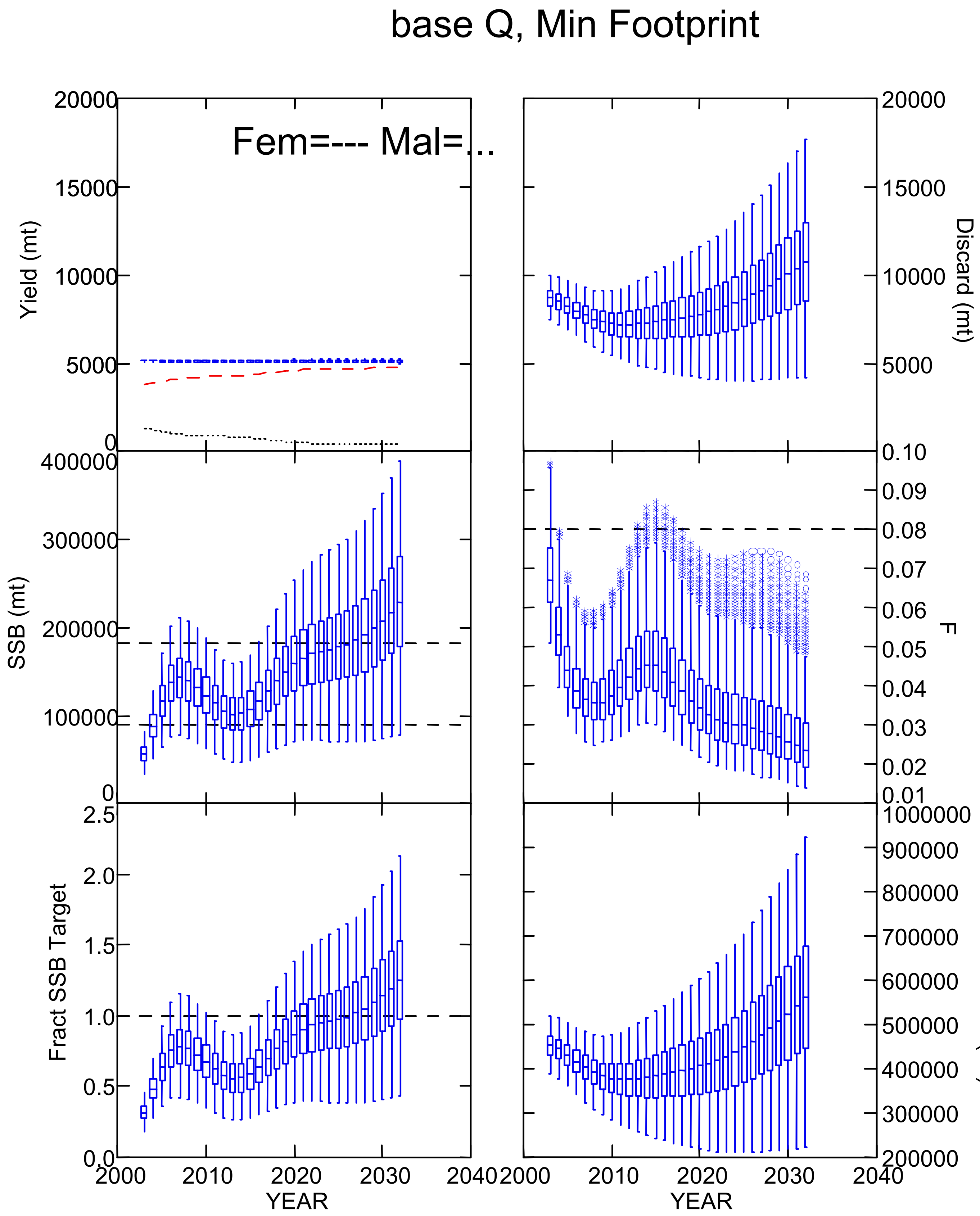


Fig. B9.4 Summary of projection model simulation results under the baseline Quota scenario. Minimum footprint is assumed. See text for details.

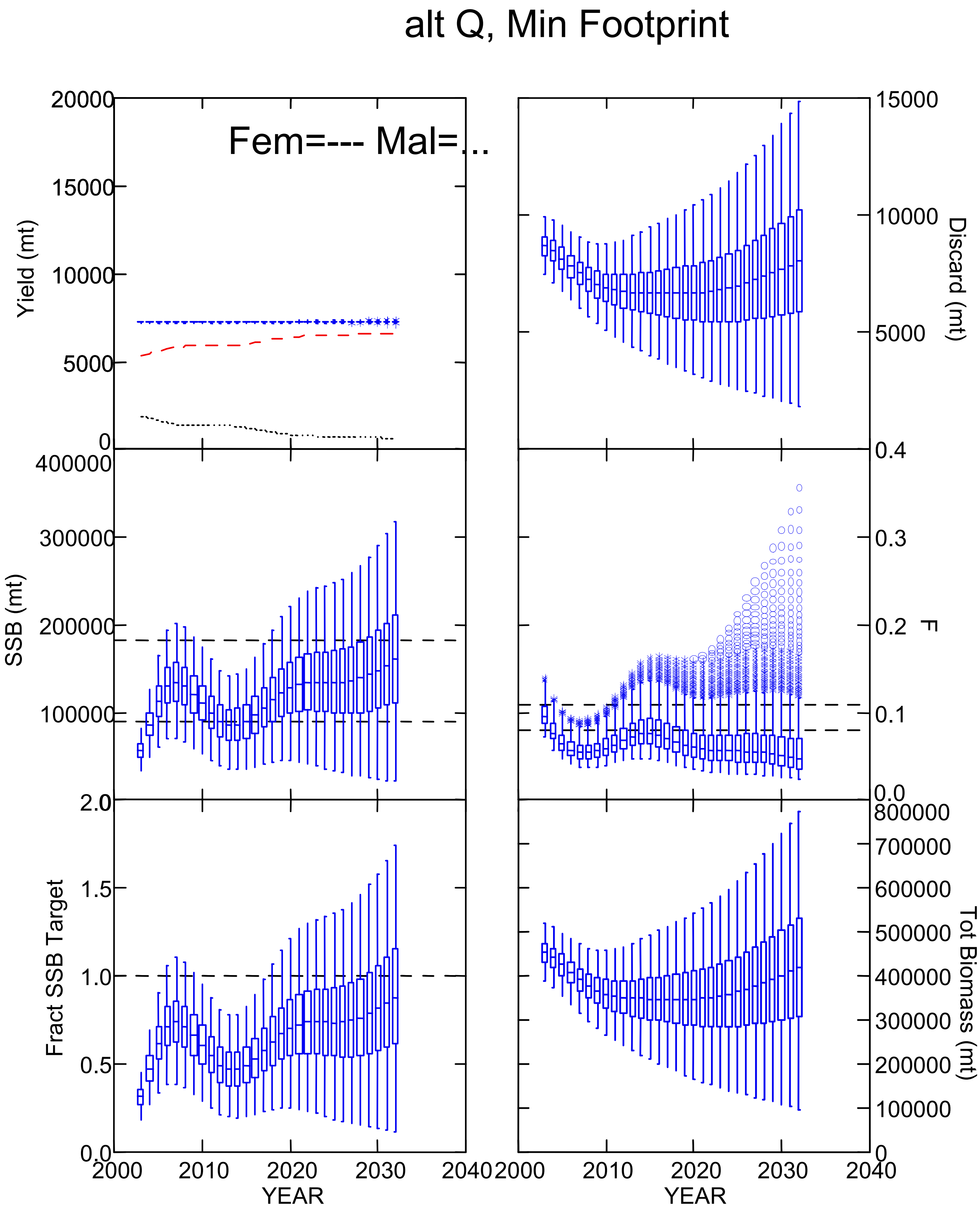


Fig.B 9.5 Summary of projection model simulation results under the alternative Quota scenario. Minimum footprint is assumed. See text for details.

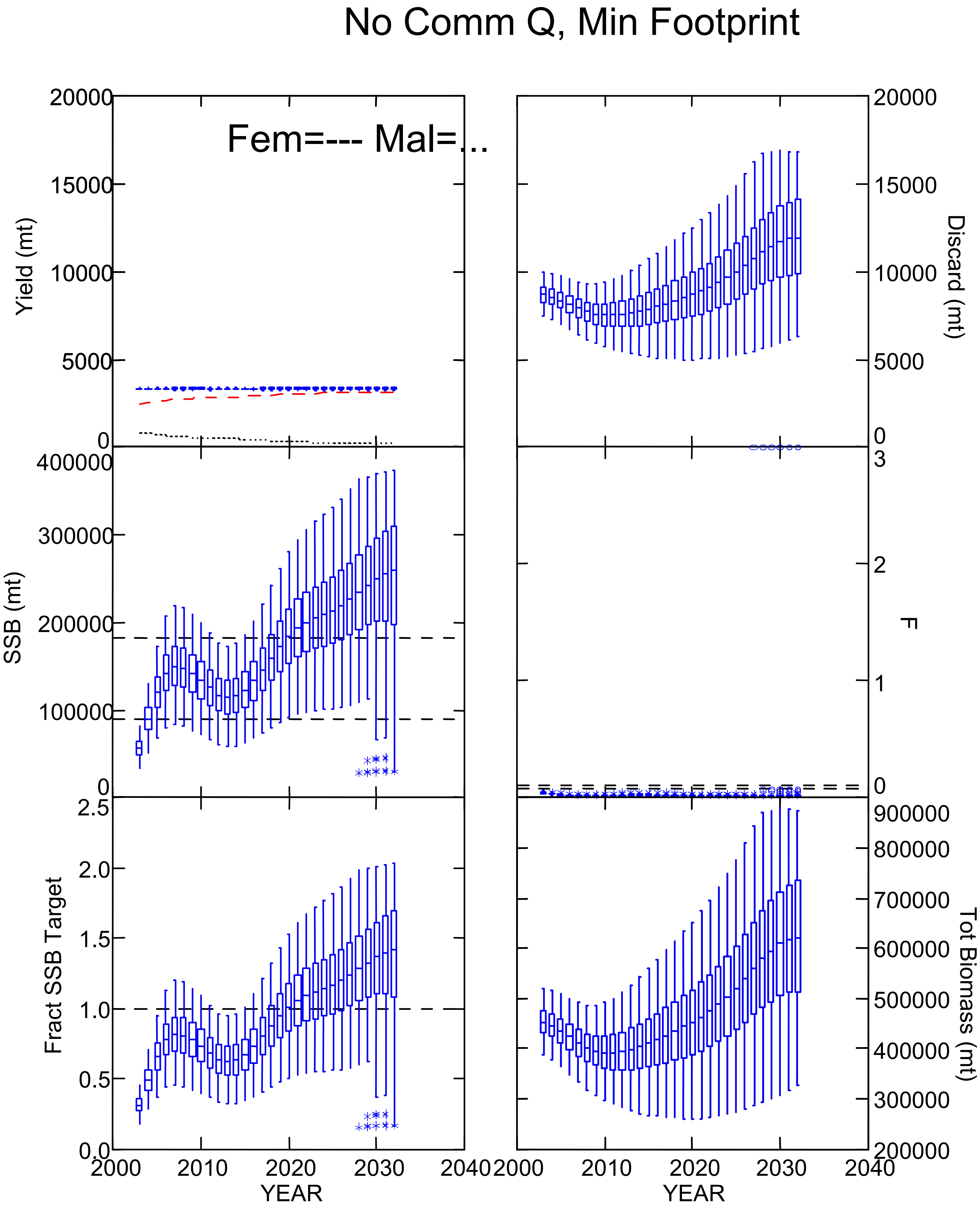


Fig. B9.6 Summary of projection model simulation results under the No Commercial Quota scenario. Minimum footprint is assumed. See text for details.

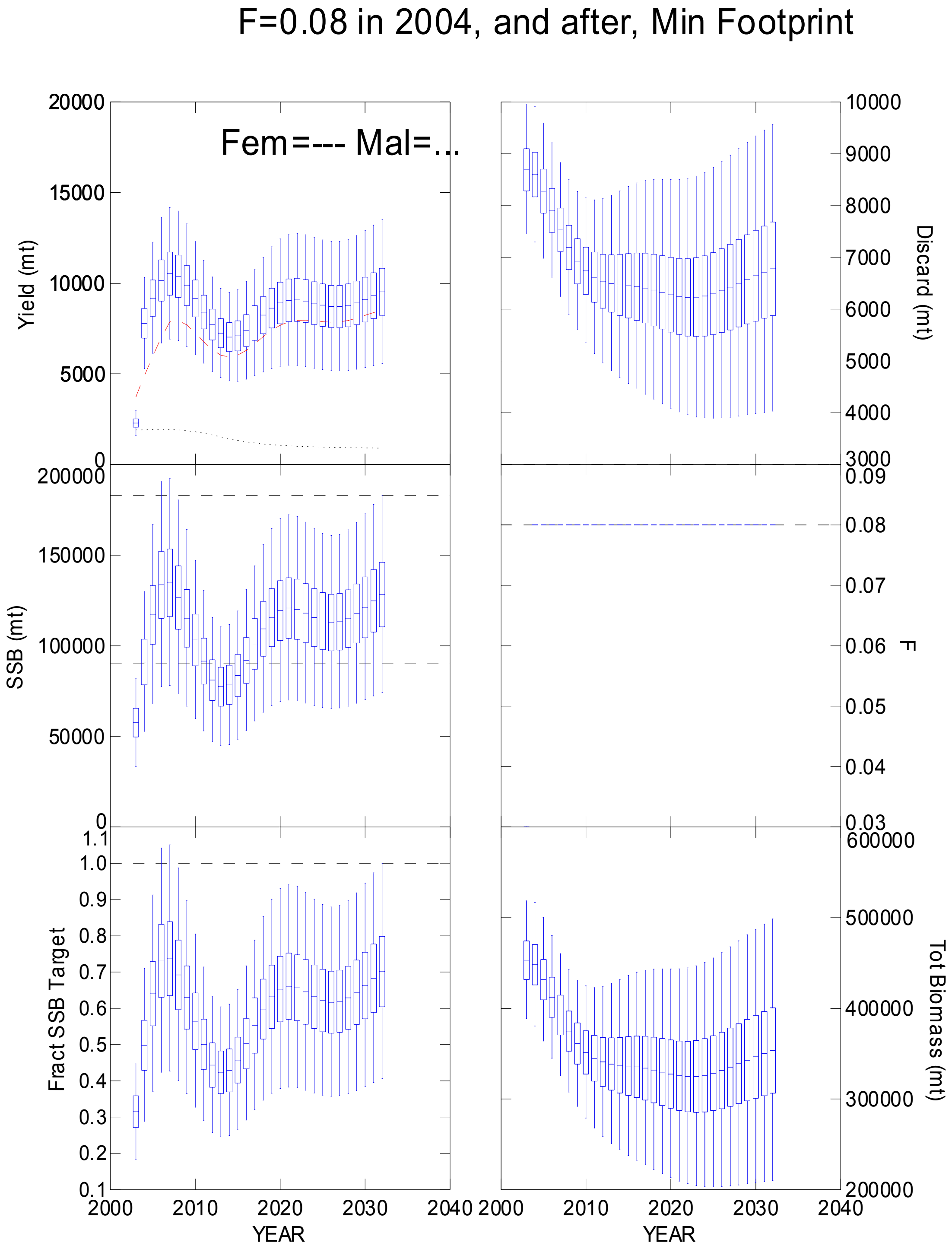


Fig. B9.7 Summary of projection model simulation results under the federal FMP specified F level of 0.08 in 2004. See text for additional details.

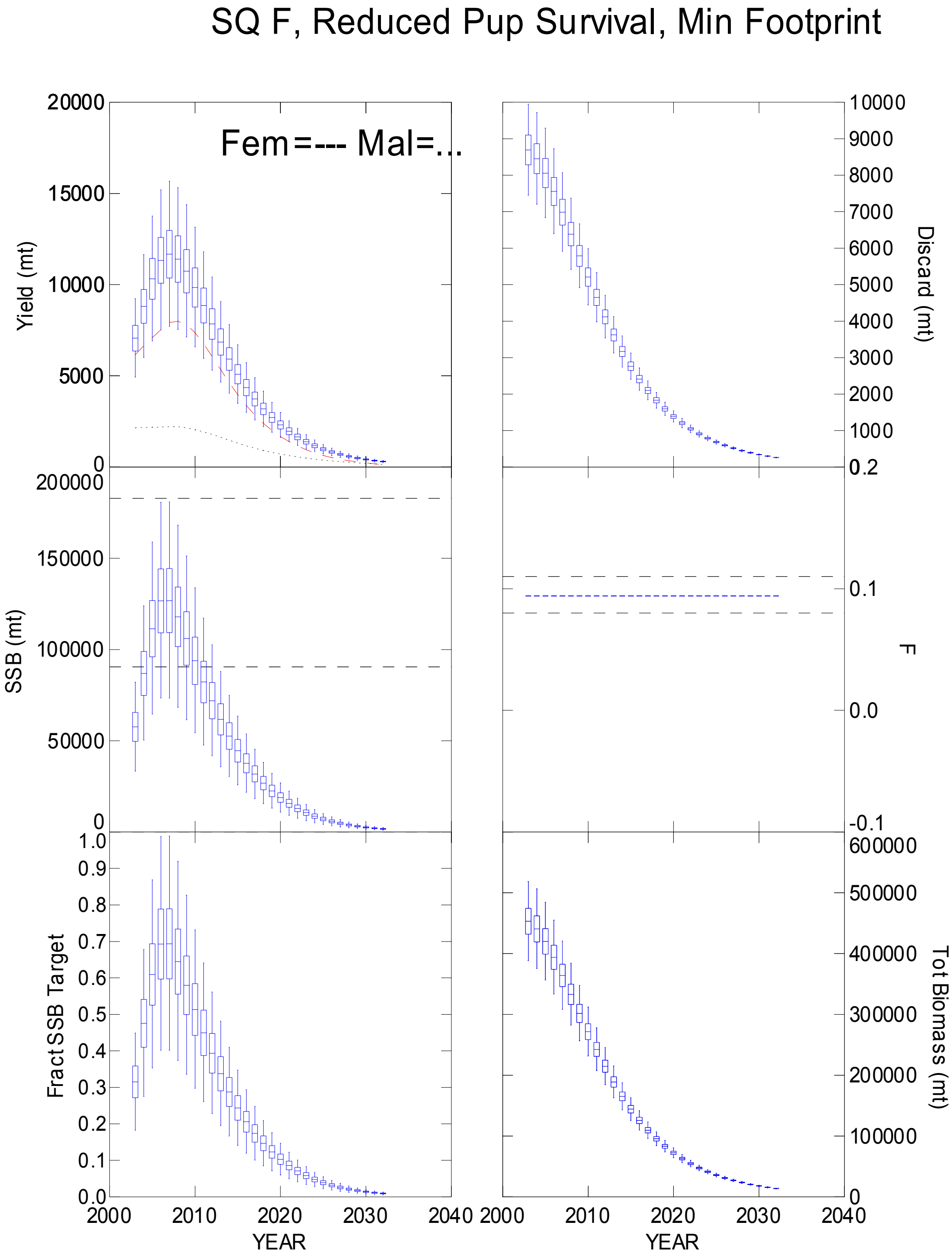


Fig. B9.8 Summary of projection model simulation results under the assumption that the status quo F continues and first year pup survival is expressed as a function of maternal size. This scenario suggests that the population will neither rebuild or stabilize under the status quo F. See text for additional details.

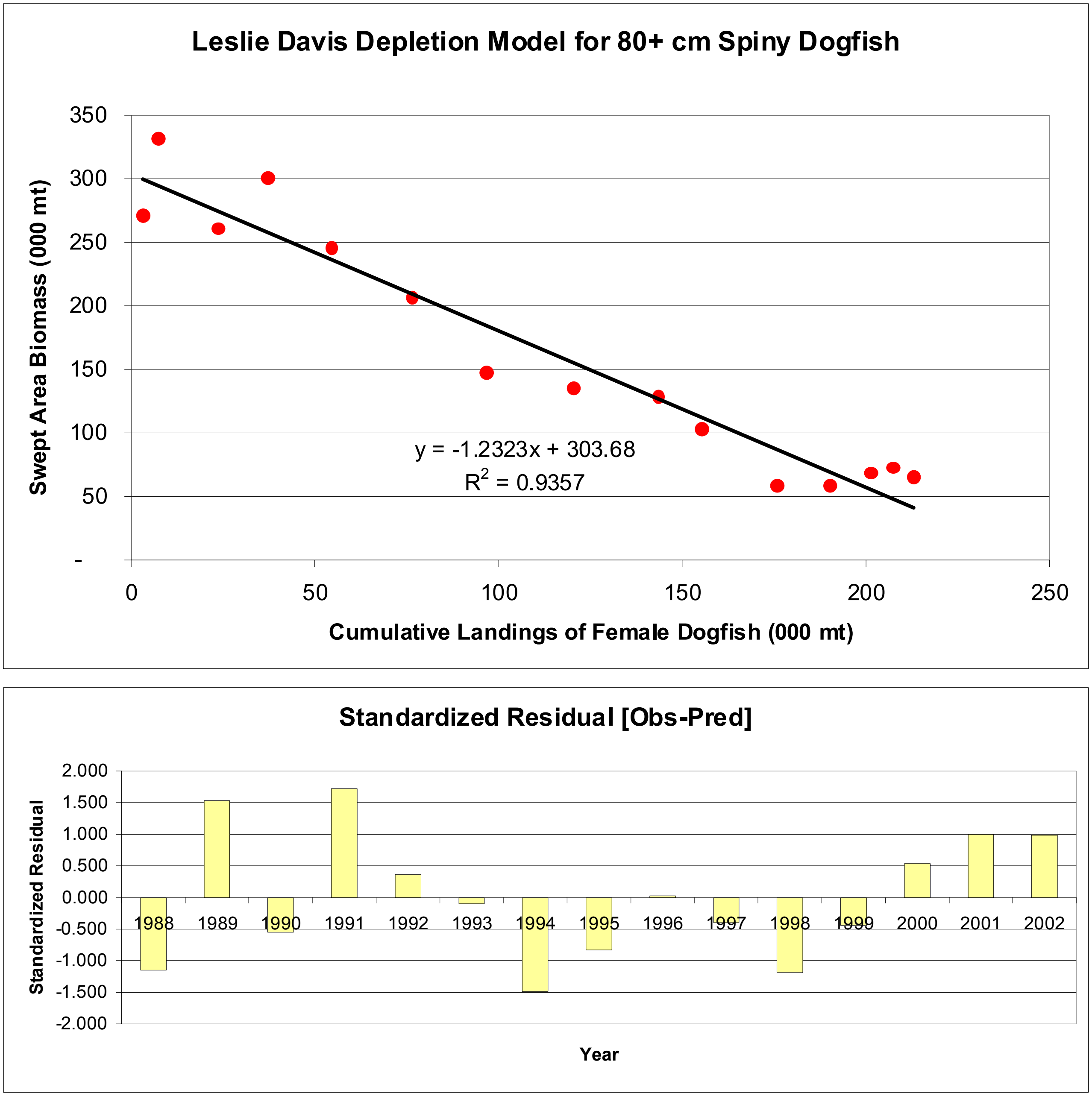


Fig. B10.1. Summary of Leslie-Davis depletion model for female spiny dogfish, assuming a closed population. See text for additional details.

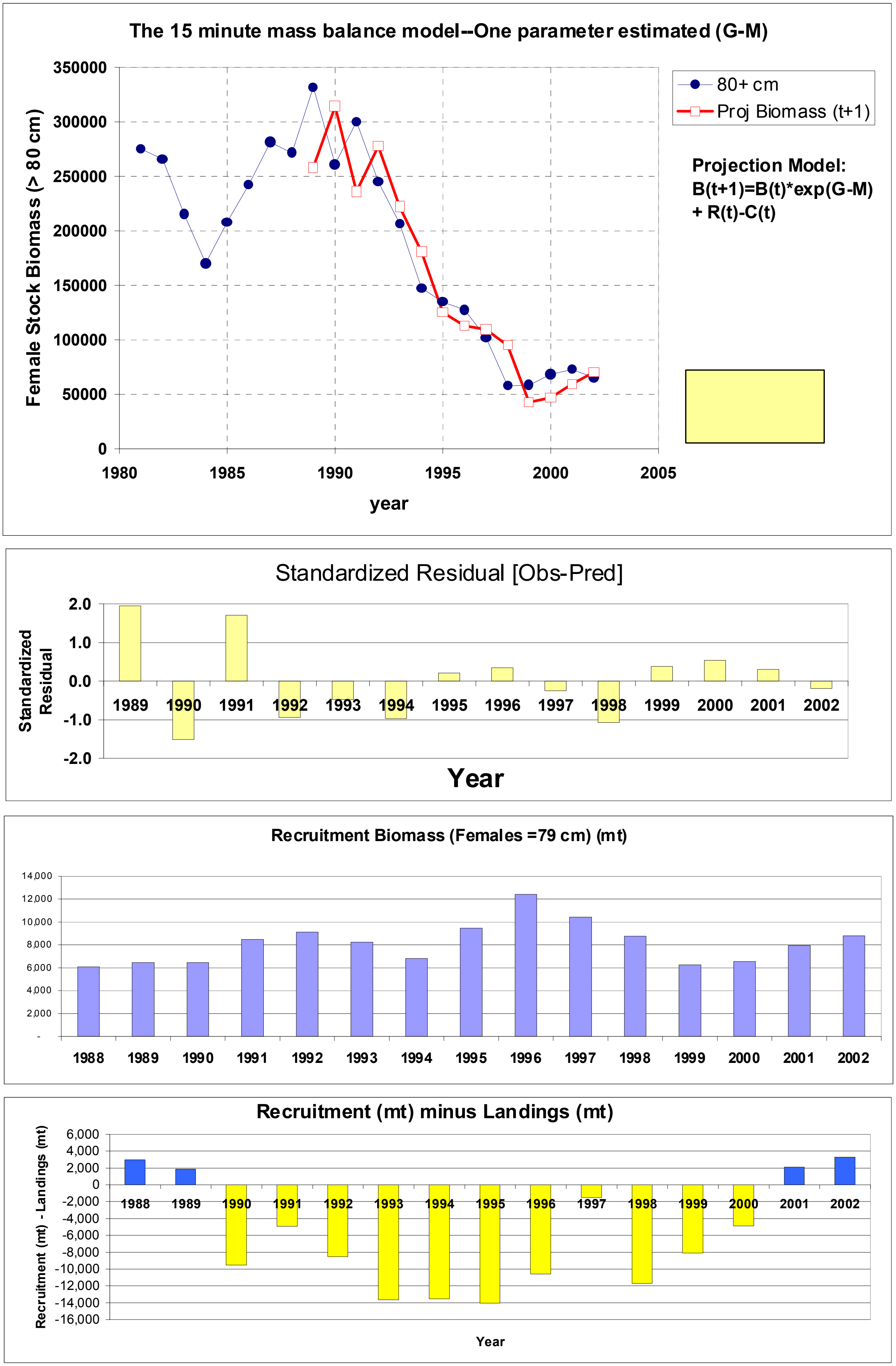


Fig. B10.2. Summary of one-parameter mass balance model. See text for details.