MID-ATLANTIC FISHERY MANAGEMENT COUNCIL

Richard B. Robins, Jr
Chairman

Lee G. Anderson
Vice Chairman

ROOM 2115 FEDERAL BUILDING
300 South New Street
Dover, Delaware 19904-6790
Tel 302-674-2331
Toll Free 877-446-2362
FAX 302-674-5399

Daniel T. Furlong
Executive Director

DATE: November 4, 2009

TO: NEFMC

FROM: MAFMC Staff

SUBJECT: Briefing materials regarding *Dogfish* specifications

Please find enclosed the following briefing materials:

(Page 2) A. Oct. SSC Minutes (includes Spiny dogfish ABC)

(Page 6) B. Report for SSC: Update on the Status of Spiny Dogfish in 2009 and Initial Evaluation of Alternative Harvest Strategies

(Page 40) C. Presentation to SSC on Spiny Dogfish Update

(Page 50) D. Staff Recommendations to SSC & Monitoring Committee

Note: While the briefing items may have their own page numbers, for referencing convenience an overall briefing page number has been added at the center-bottom of each page in an underlined larger font.

Briefing Item A: Mid-Atlantic Fishery Management Council
Scientific and Statistical Committee Meeting Minutes
Baltimore, MD
October 27, 2009

The following members of the MAFMC SSC were in attendance: John Boreman (Chair), Tom Miller (Vice Chair), Marty Smith, Brian Rothschild, Chris Moore, Wendy Gabriel, Scott Crosson, Yan Jiao, and Mike Wilberg. Also in attendance were Fred Serchuk (NEFSC), Paul Rago (NEFSC), Katherine Sosebee (NEFSC), Lee Anderson (MAFMC), Rich Seagraves (MAFMC), Jim Armstrong (MAFMC), Chris Vanderweidt (ASMFC), and Eric Brazer (CCCHFD).

Agenda Item 1: ABC Recommendation for Spiny Dogfish for Fishing Year 2010 (May 1, 2010 - April 30, 2011)

The SSC agreed by consensus to recommend that the ABC for spiny dogfish for fishing year 2010 be set at 10,064 mt based on $F_{rebuild}$=0.11. The SSC notes that because the stock has yet to be officially declared "rebuilt" by NMFS, it does not have the authority to exceed the rebuilding F.

The SSC notes that no consideration of management uncertainty is included in this advice.

Rationale
Spiny dogfish was declared overfished in 1998 and is under a federal rebuilding plan. The most recent assessment update indicates that the spawning stock biomass (SSB) of spiny dogfish is 194,584 metric tons (mt). There is a high probability that this level exceeds the overfished definition for this stock, and thus spiny dogfish are likely not overfished. The estimated SSB is close to the calculated SSB_{max} (200,000 mt). The estimated fishing mortality rate for the most recent fishing year was F=0.117. Stochastic modeling indicates that this value does not overlap with the overfishing definition (F=0.39). Thus the spiny dogfish stock is not experiencing overfishing.

Spiny dogfish spawning stock biomass (SSB) appears to have reached or exceeded the rebuilding target (SSB_{max} = 200,000 mt adult female biomass) in the most recent years. The Agency had not made a determination that the stock was rebuilt even though the stock has reached or exceeded its rebuilding target. The SSC was informed accordingly that it was constrained to choose an F that could note exceed the rebuilding F, F=0.11 The SSC notes that spiny dogfish was declared "rebuilt" by the ASMFC in its jurisdiction in 2008. The SSC believes that an updated stock status determination by NMFS is warranted.

Until such time, the SSC is constrained by the rebuilding plan, which establishes $F_{rebuild}$=0.11 as the OFL. The SSC recommends setting ABC=OFL. This approach provides a 50% risk that the realized catch will exceed the catch associated with the OFL. However, the recommended ABC (10,064) has a very low probability of exceeding the overfishing level and, of the options considered, had the highest probability of rebuilding the stock. Based on projections at F=0.11, there is a 61.2% chance that SSB_{2010} will exceed the biomass rebuilding target and SSB is expected to increase by 18.5% compared to 2009.

It is noted in the assessment update that although the population's long term dynamics (based on projections) are inherently uncertain, the projections are a useful guide for short term harvest policy. All of the projection scenarios exhibited a future decrease in SSB (beginning around 2012) resulting from the apparent protracted period of low recruitment during the period 1997-2003. Among the harvest scenarios considered, the F=0.11 scenario minimized the low point in projected SSB resulting from this hiatus in recruitment.

Sources of Scientific Uncertainty

There are uncertainties in both the data and the models used to estimate population abundance, fishing mortality, and biological reference points. Commercial landings were assumed to be measured without error. In addition, discards represent a large source of fishing mortality relative to landings. Estimates of fishing mortality based on the stochastic method include the uncertainty associated with discard estimates and recreational landings and discards. Estimates of discards for the Canadian fishery are not available. The projection model, however, does not incorporate the magnitude of discard uncertainty in forecasts of future population size. Therefore, discard estimates represent a large source of uncertainty that is addressed in the assessment model but are not accounted for in the projection model. In addition, the assumed rates of discard mortality by gear type (i.e., trawls, gill nets, recreational hook and line) are uncertain.

No uncertainty in biological reference points was considered in harvest projections. In addition, stock projections assumed a linear relationship between adult female stock size and recruits. Alternative stock-recruitment relationships (i.e., Ricker function) should be considered in future projections.

The simple arithmetic average of stock size did not incorporate sampling variations in the underlying survey data or uncertainty in the size of the footprint of the average trawl tow. However, the stochastic model for swept-area biomass accounts for survey sampling design variability (i.e., variance of mean relative density estimate), inter-annual variation in density of the three year moving average, and the variability in the footprint of the average trawl tow. The variance in the calibration coefficient used to convert Bigelow survey indices to Albatross equivalents was incorporated in the analysis of fishing mortality in 2008 and population size in 2009. These sources of uncertainty are incorporated into distribution of the initial population sizes used in the projection model

Special comments
The ABC recommendation for spiny dogfish for fishing year 2010 took into account scientific uncertainty only and did not account for management (i.e., implementation) uncertainty.

The ABC recommendation applies to all sources of fishing mortality on spiny dogfish in the Northwest Atlantic Ocean (i.e., US and Canadian landings and discards).

Agenda Item 2: Role of SSC Members relative to the SAW/SARC process

The Council has agreed, when possible, to provide an SSC member to Chair SARC meetings. In addition, the SSC has designated a member to serve as the species lead for each MAFMC managed species. Species leads were encouraged to attend assessment working group meetings early in the process to become familiar with the issues related to stock assessments for which they were given responsibility. The issue is what level of involvement/participation in the SAW working group is appropriate for SSC members. The consensus of the SSC was that SSC members should become fully engaged in the assessment working group process so that they not only become familiar with the assessments, but they also can provide value added to the assessment process and products through their contributions at the working group level. It is a far better outcome and better use of limited scientific resources and expertise to have SSC concerns or suggestions addressed by the Working Groups as early as possible in the process rather than at the SSC review and ABC specification level. However, once an SSC member becomes an active participant in the assessment process, it is inappropriate for them to serve as the SARC Chair.

Agenda Item 3: Conditions for Council Remand of SSC ABC Recommendations

The Council has requested SSC input on conditions where it would be appropriate for the Council to remand an SSC ABC recommendation back to them for reconsideration. The SSC agreed by consensus that one condition that clearly warrants SSC reconsideration of an ABC recommendation is when an error in computation has occurred. The SSC also agreed that a remand is warranted if the SSC did not address the terms of reference for the topic to which they are responding. This will require establishment of formal TORs for all requests directed to the SSC from the Council. Another condition discussed is when new information becomes available following an SSC ABC determination. While under special circumstances this condition might warrant reconsideration, the SSC concluded that, in general, consideration of information to be included in stock assessments should be introduced early in the stock assessment process and review of additional information not included in stock assessments or status updates would, in most cases, be inappropriate. The last situation discussed was the case where the SSC did not have a quorum present when the ABC determination was made. There was general agreement that having a quorum present is a necessary prerequisite for ABC determinations. In order to insure that the SSC has a quorum present, SSC members could be provided with remote access to the meeting via conference call or other mechanisms to allow for their remote participation in the ABC discussions. It was also generally agreed that the SSC operates most effectively when meeting face to face and that members should make every attempt to attend the meetings in person. The use of the remote access option should be used only as a fall back provision to insure that a quorum of the SSC participates in the meeting. Council staff is working on a meeting schedule that allows for at least 3-6 months advance notice of upcoming SSC meetings. In summary, the following conditions for remanding ABC recommendations back to the SSC will be forwarded to the Council:

1. A computational error was subsequently detected that may affect the basis for an SSC ABC recommendation.
2. The SSC did not fully address the terms of reference provided by the Council for an ABC recommendation.
3. A quorum was not present at the meeting where the SSC formulated an ABC recommendation.

The SSC also agreed that a set of standard operating procedures needs to be developed to guide the operation of the SSC.

ACTION: Draft standard operating procedures for the SSC (Boreman, Miller, Seagraves)

Agenda Item 4: Management Strategy Evaluation (MSE) Proposal Update

Mike Wilberg gave a brief update on the status of the MSE proposal developed by the SUN Subcommittee. The proposal has been submitted to the MAFMC and the Council has committed to funding the project. Mike Wilberg and Tom Miller are currently seeking a Post Doc candidate to conduct this work.

Agenda Item 5: Review of Council's Five Year Research Plan

Council staff distributed a revised draft of the existing MAFMC Five Year Research Plan research plan for SSC review and comment. SSC discussion noted that the research needs list is heavily oriented to stock assessment needs and the Council plan should also address research needs relative to social/economic and protected resources issues.

ACTION: The SSC Species Lead should review the research needs list for their respective species and provide comments. Comments need to be received by **COB Friday November 20, 2009** for inclusion of the revised plan in the December Council meeting Briefing Book.

Briefing Item B: Update on the Status of Spiny Dogfish in 2009 and Initial Evaluation of Alternative Harvest Strategies

Paul Rago and Katherine Sosebee
Northeast Fisheries Science Center
National Marine Fisheries Service

Mid Atlantic Fishery Management Council
Science and Statistical Committee
October 15, 2009
Last Update October 21, 2009

This information is distributed solely for the purpose of pre-dissemination peer review. It has not been formally disseminated by NOAA. It does not represent any final agency determination or policy.

Overview

The purpose of this report is report is to summarize the most recent information on the status of spiny dogfish (*Squalus acanthias*) in 2009. Information on survey trends and total removals are provided along with an analysis of estimated stock size, fishing mortality rates, and projections of stock size under varying fishing mortality rates.

A benchmark assessment has been scheduled for the week of January 25, 2010. This assessment will be conducted as part of the Transboundary Resources Assessment Committee (TRAC). A team of Canadian and US scientists will attempt to implement a full forward projecting size-based assessment model.

This report draws heavily on the results of the last peer-reviewed stock assessment vetted at SARC 43 in 2006. In particular, key assumptions related to the size- and sex-based selectivity of the fishery, and biological reference points were retained in this analyses. All of these assumptions will be revisited when the stock is reassessed in the TRAC benchmark in 2010.

A. Catch Trends

1. This document summarizes the most recent information on spiny dogfish stock status using survey data from the spring 2009 NEFSC bottom trawl survey and catch data from 2008. Catch data include landings from US and Canadian commercial fisheries, and US recreational landings. Discard information includes discards from US commercial fisheries and US recreational fisheries. Estimates of dead discards are obtained by multiplying the total discards by the gear-specific discard mortality rates.

2. Total catch in 2008 was 19,974 mt. Estimated total removals, the sum of landings and estimated dead discards were 10,828 mt. This represents a decline of 1,308 mt from 2007. Most of this change is due to reductions in dead discards, particularly in the otter trawl fishery. Preliminary estimates of landings, discards and dead discards in 2008 are provided below.

Gear (fraction dead)	Discard (mt)	Dead Discards (mt)	Landings (mt)
Otter Trawl (0.5)	5,604	2,802	
Sink gill net (0.30)	4,864	1,459	
Line Trawl + Scallop Dredge (0.1)	497	49.7	
Recreational Discards (0.2)	3,115	622.9	
Recreational Landings			213.6
US Landings			4,108.2
Canadian Landings			1,572.3
TOTAL	14,080	4,934	5,894.1

3. Commercial landings for NAFO Statistical Areas 2-6 are summarized in Figure 1a and Table 1. Total landings of spiny dogfish by all commercial fleets increased rapidly from the late 1960s, peaking at around 24,500 mt in 1974. A substantial foreign harvest of dogfish occurred between 1966 and 1977, exceeding 24,000 mt in 1972 and 1974, but subsequently never higher than 1,000 mt. Between 1979 and 1989, total landings averaged only 6,100 mt per year, but increased sharply to above 17,000 mt in 1990 and exceeded 28,000 mt in 1996. In 1999, the last full year prior to implementation of domestic regulations, US commercial landings were 14,860 mt.

4. By 2001, US landings had declined to 2,300 mt in response to regulations imposed by both federal and the Atlantic States Marine Fisheries Commission (ASMFC) management plans. Reduced US landings in waters were offset somewhat by an increase in Canadian landings from 416 mt in 1996 to an average of 2,400 mt between 2000 and 2005. Total landings have increased since 2003 to almost 6,000 mt, but are well below the long term average.

5. Spiny dogfish harvested by the distant water fleets were caught almost entirely by otter trawls. US landings have been taken primarily by otter trawls and sink gill nets. Trawls were the predominant gear through the 1970s and into the early 1980s, but sink gill nets were the primary gear during the directed fishery in the 1990s. Landings in otter trawls ranged around 3,000–5,000 mt during this period.

6. No new estimates of composition of the landings and discards by sex were computed for 2008. Instead the sex ratios were assumed to be the same as in the last peer-reviewed estimates in SARC 43.

7. Similarly, the selectivity pattern of the overall fishery for both males and females was assumed to be the same as in SARC 43.

8. Total dead discards declined rapidly from nearly 20,000 mt during the early 1990s to about 4,000 in 1998 (Table 2). Discards have been relatively stable since then with a modest increase in recent years to nearly 6,000 mt. (Fig. 1b)

B. ***Survey Indices***

1. The NEFSC spring bottom trawl survey in 2009 was conducted by the FSV Bigelow instead of the R/V Albatross IV. The Bigelow is a larger, acoustically-quiet vessel. It tows a larger net and has different sampling protocols. A large-scale side-by-side calibration experiment was conducted in 2008 to compare catches between the two vessels. A peer-review committee met in August 2009 to review the results of the experiment and to provide additional guidance on methodology for estimating the magnitude of the gear-vessel-protocol differences. Final results from the review have not been published. This update for spiny dogfish represents the first use of the new survey time series and proposed conversion factor.

2. The calibration factor for spiny dogfish was estimated using a beta-binomial estimator. Overall the Bigelow caught 1.1468 times as many spiny dogfish per tow as the Albatross. The standard error of the estimate was 0.0441 and the 95% confidence interval was 1.0636 to 1.2365. The 2009 Bigelow-based estimates of relative abundance were converted to predicted Albatross equivalents by dividing each estimate by 1.1468.

3. The use of a calibration coefficient increases the variance of the estimated Albatross equivalent because this prediction includes the sampling errors of the original Bigelow survey value and the calibration coefficient. A Taylor series expansion method was used to estimate the variance as
   a. $Var\left[\frac{I_{Bigelow}}{\gamma}\right] = \frac{Var[I_{Bigelow}]}{\gamma^2} + \frac{I^2_{Bigelow}Var[\gamma]}{\gamma^4}$
   b. The average number of female dogfish per tow by the Bigelow was 30.3 with a standard error of 4.3. The predicted Albatross equivalent was 26.4 per tow with a standard error of 5.8.
   c. The average number of male dogfish per tow by the Bigelow was 58.3 with a standard error of 9.87. The predicted Albatross equivalent was 50.8 per tow with a standard error of 8.82
   d. The increased variance of the estimates was modest with less than a few percent increase in the coefficient of variation.

4. The conversion factor for average weight per tow for spiny dogfish of 1.1044 was nearly equivalent to the calibration coefficient for average number per tow. The near equivalency of these two metrics suggested that there was little appreciable differences in size selectivity. A comparison of size frequency distributions of male and female spiny dogfish (Fig. 2a) in the spring of 2008 revealed no direct evidence of important differences in size composition. It should be noted that estimates in Fig 2a are not adjusted for the calibration coefficient. The survey comparisons suggest remarkable similarity in both overall magnitude and size composition.

5. The swept area biomass estimate of spiny dogfish in the 2009 NEFSC spring bottom trawl survey was 557,900 mt. The three-year moving average in 2009 was lower than the three-year average for 2008 largely due to lower estimate of mature female spawning stock (Table 3). As noted in previous assessment documents, the variations in swept area abundance estimates between years reflect both sampling variability and availability within the survey area. The three-year moving average of female SSB fell from 218 k mt

to 183.7 k mt. These swept area estimates are based on the nominal footprint of 0.01 nm^2. The 2009 estimate is below the biological reference point of 200 k mt based on this same nominal footprint. A more explicit treatment of the uncertainty in the biomass estimator is addressed later in the stochastic biomass and fishing section (See bullets C1 to C7)

6. The size composition of the female stock is summarized in Fig. 2 for 3-yr stanzas, beginning with 1989-1991 to 2007-2009. The effects of the fishery removal of large females is evident through 2000. After about 1997, recruitment markedly declined. The consequences of the low recruitment during 1997-2003, are evident in the progressive decrease in the abundance of spiny dogfish less than 70 cm. Recruitment since 2003 has shown a modest increase but no cohorts in the 40 to 60 cm range are evident. Survey catches in 2004-2006 show a general increase in recruits <35 cm. The 2007-2009 estimates reflect a pronounced increase in recruitment. with much greater values in the <50 cm range than have been observed in over a decade.

7. Male size frequency compositions (Fig. 3) do not show the effects of fishery changes on mature fish as they constituted a very small fraction of landings. Trends in reduced pup production and subsequent reduction of male dogfish between 40 to 65 cm parallel the changes observed for female dogfish. Evidence suggests that recruitment has increased in recent years. Abundance of 36-79 cm male dogfish has increased to about 300,000 mt in 2009

8. The relationships between trends in mature (≥80 cm) and immature (36-79 cm) components of the female dogfish are shown in Fig. 4. The reduction in the immature female size range reflects both their growth into the mature stock and the reduction in recruitment. Comparison of the diverging trends in immature and mature components suggests that the increase in recent spawning stock biomass is fueled in part by growth of dogfish out of the 36-79 cm size range to 80+ cm range. Reductions in the 36-79 cm size range are also driven by reduced recruitment between 1997 and 2003.

9. Changes in recruitment are illustrated in Fig. 5. Interannual variations in abundance are high but patterns after 1997 show a marked decline. Recruitment estimates from 2005 to 2008 are moderately higher and the 2009 estimate is one of the highest on record. As with all such estimates, it remains to be seen if this year class is as strong as it initially appears.

10. No strong trends in abundance of large male dogfish (≥80 cm) are evident (Fig. 6 top) and total biomass of this component appears to be negligible. Male dogfish from 36 to 79 cm have increased steadily since 1980 from about 100,000 mt to 300,000 mt in 2009. (Fig. 6 bottom).

11. As a result of the reductions in mature females from harvest and limited removals of males, the sex ratio of mature male (≥60 cm) to mature female (≥80 cm) dogfish has changed markedly (Fig. 7). Owing to the earlier maturation of males and assuming comparable natural mortality rates between males and females, life history theory suggests that the expected ratio of mature males to females should be about 2:1. Current estimates of the ratio are in the neighborhood of 3.5:1. The Lowess smooth of the estimated ratios has declined since about 2002.

C. Stochastic Estimates of Biomass and Fishing Mortality

1. The simple arithmetic average of stock size does not incorporate sampling variations in the underlying survey data or uncertainty in the size of the footprint of the average trawl tow. A stochastic estimator of spawning stock biomass for female dogfish is described in SARC 43. Results of this estimator are depicted in Fig. 8. Computational details on this estimator may be found in Rago and Sosebee (in press).

2. The mean stochastic female SSB estimate for 2009 of 163,256 mt represents a slight decline from the 194,616 mt (based on the 2006-2008 data) but an increase from 141,350 mt in 2007 (2005-2007 data). Each estimate includes 3 years of data; the year identifies the last year in the 3-yr average.

3. The incorporation of a larger average size trawl footprint reduces the target female SSB level to 167,800 mt from 200,000 mt. We emphasize that this change is due to the rescaling of the survey data associated with the increased footprint size.

4. The uncertainty of the female spawning stock biomass estimate and its relationship to the target and threshold values is depicted in Fig. 8 (top). There is about a 99% probability that female SSB in 2008 exceeds the female threshold biomass level (83,900 mt). The probability that female SSB in 2008 exceeds the target biomass of 167,800 mt is about 43 %

5. The cumulative distribution functions for SSB and exploitable biomass of male and female spiny dogfish (Fig. 8 bottom) illustrate the uncertainty in the estimates of biomass. The median total biomass estimate for spiny dogfish is slightly more than 500,000 mt. Exploitable biomass is a function of the selectivity pattern in the fishery. Because the recent fishery harvests the largest fish in the population, the median exploitable biomass of female dogfish is 76,000 mt is lower than the female spawning stock biomass. Median exploitable biomass of male dogfish is about 270,000 mt.

6. The estimator for fishing mortality is based on the ratio of total catch and swept area biomass. Ostensibly this assumes that the trawl is 100% efficient in capturing dogfish between the wings. Alternatively, it implies that the trawl is about 50% efficient in capturing dogfish between the doors. An external mass balance model was first applied at SARC 43 and has been recently updated for a chapter in a forthcoming book on spiny dogfish (Rago and Sosebee in press, AFS). The mass balance model supports the biomass estimates based on simple swept area concepts. However, it is acknowledged that this is a source of uncertainty in the assessment and subject to change at a future benchmark assessment.

7. Preliminary comparisons of the average catch rates of the Bigelow and Albatross, the derived calibration coefficient and consideration of average area swept per tow for each gear type suggest that the upper bound on efficiency of capture for dogfish encountered between the doors on the Albatross net is on the order of 0.63. This bound scales directly with the assumed capture efficiency of the Bigelow net. See Appendix 1 for details on this calculation.

8. The derived sampling distribution of fishing mortality on the exploitable population is depicted in Fig. 9. Using the current selectivity pattern, F in 2008 on the exploitable female stock was F=0.117, well below the threshold F of 0.39 and the target F of 0.284 (which gives 1.5 female pups per female recruit). The 90% confidence interval is (0.08 to 0.154). The current F is roughly equal to the rebuild F=0.11.

9. The threshold biological reference points for fishing mortality is 0.39. This is uncharacteristically high for elasmobranch species but it is explained by the selectivity pattern of the fishery which harvests the largest fish in the population, thereby delaying the force of mortality to older individuals. The ultimate measure of the effects of varying selectivity patterns are their consequences for net reproductive rate. For spiny dogfish, net reproductive rate is expressed as female pups per recruit. An infinite number of selectivity and fishing mortality rates can generate the same value of pups per recruit. One challenge that arises is that shifts in selection toward smaller fish can rapidly change the estimates of derived full F and the associated biological reference points. As an example, increased harvesting of smaller fish in a directed fishery would shift the force of mortality to younger fish and decrease the biological reference point from 0.39 to much lower values.

10. Overall, the fishing mortality rates on spiny dogfish are very low. Fishing mortality rates on the total stock are less than 3%.

11. It is important to recognize that the uncertainty in the estimate of F is a function of uncertainty in the survey density estimate, the variability in the footprint size, variability in the recreational catch, and variability in the discards by gear and sex. Additional details on this estimation approach may be found in Rago and Sosebee (in press) and SARC 43.

D. Harvest Scenarios

1. The projection model for spiny dogfish was revised to incorporate the following changes:

    a. A separate F for each sex. This was important because of the spatial segregation of the fishery and to accommodate options that might include changes that target male dogfish offshore.
    b. The model now summarizes landings, discard and catch for each sex. Discards are obtained by multiplying the catch by an average discard fraction by sex.
    c. The average discard fraction was estimated as the ratio of discards to catch in 2008.

2. Current stock status is consistent with projections made at SARC 43. (Fig. 10). Realized female SSB estimates in 2006, 2007, 2008 and 2009 are within the interquartile range of projections made in 2005 under the Frebuild scenario.

3. Four different projections were considered. The long lifespan and slow growth of spiny dogfish implies long-term transient behavior. For example, the low average numbers of individuals between 40 and 65 cm has implications for the next 20 years of stock dynamics. Projections were conducted for 30 years but, to improve readability, results are only presented for 20 years from 2009 to 2028.

4. The F-based projections were based on the status quo F (female F_{2008}= 0.117; Fig. 11); the previously derived Frebuild =0.110; Fig. 12); and the target and threshold Fs equal to the biological reference points (0.284 and 0.390, respectively; Figs. 13 and 14).

5. Each of the scenarios is summarized by a time series plot of female SSB, the ratio of current stock size to the rebuilt status, and either catch or fishing mortality. For the F-based scenarios (Figs. 11-14) , box plots are used to summarize the distributions of total catch, landings, and discards.

6. Each scenario is also summarized with a table that illustrates the 30 year trend in average stock size, landings, and discards by sex. (Tables 4-7). The table also includes three ratio estimates of stock performance. The first is a measure of the average ratio of SSB to the reference female SSB (167,800 mt). The second and third represent the fraction of the simulations in which population size exceeds either the target or threshold SSB values.

7. All of the scenarios assume that survival of pups is at the long term average (0.68 based on the model described in SARC 19, and also in Rago et al. 1998). All of the projections will be optimistic if this assumption is not true. Scenarios with alternative values of pup survival have not been run, but the long term population biomass will scale proportionally to the magnitude of pup survival. For example, a harvest rates that leads a long term population size of 200,000 mt when pup survival is 0.68 would be 100,000 mt if pup survival were 0.34.

8. A common feature of all the scenarios is an oscillation as the present population increases through growth and declines as the last decade's low recruitment enters the adult population. Only after the new recruits begin to contribute to the population does the population continue its rebuilding path.

9. F-Status quo Projection. Fig. 11 and Table 4 Under this scenario, F=0.117 on females results in continued increase in SSB through 2011 followed by a gradual decline to below the target female SSB of 167,800 mt by 2014. The population is predicted to begin increasing steadily after a low point in 2018. Based on the projections, the population is expected to remain above the threshold biomass level over the entire period. Landings would be expected to increase gradually over the projection period.

10. F-Rebuild Projection. Fig. 12 and Table 5. The F-rebuild scenario is essentially equal to the status quo. The slightly lower F implies higher terminal population sizes and slightly lower landings.

11. F-target Projection. Fig. 13 and Table 6. The target F is expected to result in a PPR of 1.5. At the current selectivity pattern the target F is 0.284. Male F was assumed to be 3% of the female F of 0.284. The population oscillations are more pronounced under this scenario as the population is fished down from its currently rebuilt status. Landings would exceed 12,000 mt through 2013 but would fall gradually to about 8,500 mt in 2019. The population is expected to fall below the female SSB threshold of 83,000 mt in 2016 because the low number of recruits have not yet been replaced by the predicted recruits from 2007 to 2016. Longer term projections suggest that the oscillations would be expected to continue for several cycles before rebuilding. Average landings between 2009 and 2018 would be 11,800 mt.

12. F-threshold Projection. Fig. 14 and Table 7. A fishing mortality of 0.39 would rapidly fish down the reproductive stock to below rebuilt status by 2013 and induce long term oscillations in the population. An overfished condition would likely occur by 2015; if the high rate of F continued, the population would probably not return to rebuilt status over any reasonable forecast period. Fishing at the threshold F would produce an average catch of about 22,800 mt between 2009 and 2018 and about 13,300 of landings, assuming that nearly all of the landings are derived from large females.

E. Overfishing Limits and Sources of Uncertainty

1. Fishing at the Fmsy proxy of 0.39 results in 17,659 mt of landings and 30,121 mt of total catch (landings + dead discards) in 2010 (Table 5). Such harvest rate would induce a strong decline in SSB because the current age structure is not near an equilibrium size or age structure. The joint effects of the size selective fishery in the 1990s and the low recruitment in the mid-1990s to mid-2000s imply future oscillations in population abundance unless density dependent processes offset the predicted density independent changes. It must be remembered that spiny dogfish have relatively few such density-dependent mechanisms since growth rates are slow and large variations in pup production per female are unlikely.

2. The long term dynamics of spiny dogfish are an important guide for structuring harvest scenarios. The current size structure and sex ratio of the population have important implications for stock dynamics over the next decade. However, it should also be noted that long-term forecasts are inherently uncertain. The history of this resource during periods of high exploitation is informative about the magnitudes of likely fishing mortality rates. Changes in average size in both the surveys and landings suggest that the magnitude of population biomass from the swept area computations is approximately correct.

3. Scientific advice on catch levels for spiny dogfish needs to be carefully crafted. A longer term perspective is necessary to ensure that the transient effects of the current population size and sex structure are considered over a period of several decades. At the same time, such longer term projections become increasingly uncertain and are driven by the assumptions used to model the stock dynamics. It is imprudent to look at short term changes in harvest levels without considering the longer-term implications.

4. Given the above considerations, a possible harvest rate for an ABC might be one that:

    a. Keeps the population near the rebuilt level;
    b. Avoids rapid changes in catch levels; and
    c. Allows the population size structure to approximate a more balanced size structure and sex ratio, consistent with life history theory.

    In terms of a constant F, a fishing mortality rate in between 0.11 and 0.284 might accomplish these goals.

5. Recent changes in survey based abundance suggest that changes in availability play an important role in abundance indices. As the male population is largely unexploited, it may offer additional insights into changes in availability to the survey since interannual changes in the male component of the stock should be less variable.

6. Other smoothing approaches, particularly Kalman filters, may provide better measures of relative abundance than the current use of a 3 year average.

7. Other important source of uncertainty include
   a. Potential changes in fishery selectivity
   b. Implications of changing selectivity on estimation of biological reference points
   c. Potential inconsistency between the life history based estimates of fishing mortality rates and the biomass reference points derived from the Ricker stock recruitment curve.
   d. Total discard estimates AND estimated mortality of discarded dogfish.
   e. The absence of density dependent responses in the projection model
   f. Expected development of a more comprehensive stock assessment model in 2010 via the TRAC process.

F. Summary

The stochastic spawning stock biomass estimates suggests that the female spiny dogfish SSB in 2009 is slightly below the target biomass of 167,800 mt. The average stochastic female SSB estimate was 163,256 mt, with a 90% confidence interval from 112,000 to 215,000 mt.

The most recent stochastic estimate of fishing mortality for spiny dogfish stock indicates that *overfishing is not occurring* (probability that $F_{2008} < F_{threshold} \approx 100\%$). Total removals in 2008 were 10,828 mt corresponding to F=0.117, well below the overfishing threshold of F = 0.390 and essentially equivalent to $F_{rebuild} = 0.110$. Among the sources of removals, U.S. commercial landings comprised 4,108 mt, Canadian commercial landings were 1,572 mt, U.S. commercial discards were 4,934 mt, of which U.S. recreational dead discards were 623 mt.

The determination of rebuilt status is not without problems. The size frequency of the female population is concentrated between 75 and 95 cm with very few fish above 100 cm or below 70 cm. The low numbers of juvenile female and male dogfish imply that the population will oscillate over time. The decline will be induced by the sequence of poor recruits from the last ten years. In other words the recruitment deficit will have to be paid back.

SSB should increase again if pup survival rates begin to increase. Recruitment in the past 5 years has been modest. The recruitment estimate for 2009 was the fifth highest on record (Fig. 5). The consequences of the skewed sex ratio of 3.5:1 for mature males to mature females has unknown implications for future reproductive success.

While within-year sampling variability of spiny dogfish in NMFS spring surveys have remained fairly stable throughout the survey time series, inter-annual variability in survey-based biomass estimates require smoothing across years in order to characterize population trends.

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43rd Northeast Regional Stock Assessment Workshop (43rd SAW): 43rd SAW assessment report. US Dep Commer, Northeast Fish Sci Cent Ref Doc 06-25; 400 p.

Rago, P. J. and K. A. Sosebee (in press) The Agony of Recovery: Scientific Challenges of Spiny Dogfish Recovery Programs. 30 pp. In Gallucci et al. 2009. Biology and Management of Dogfish Sharks, x–xx. American Fisheries Society Symposium.

Rago, P. J., K. A. Sosebee, J. K. T. Brodziak, S. A. Murawski, and E. D. Anderson. 1998. Implications of recent increases in catches on the dynamics of Northwest Atlantic spiny dogfish (*Squalus acanthias*). Fisheries Research 39:165–181.

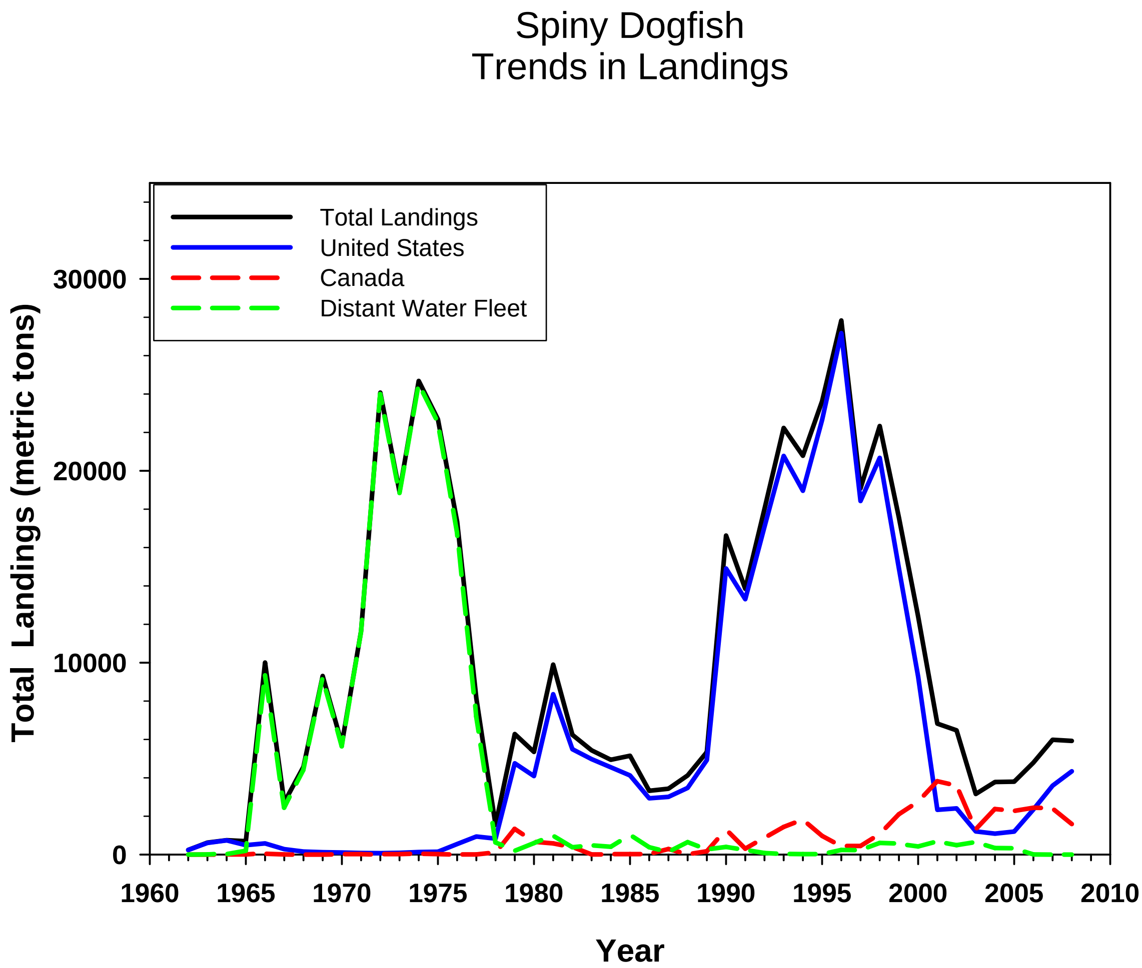


Figure 1a. Total landings of spiny dogfish by US, Canadian and foreign fleets in NAFO Statistical Areas 2-6, 1962-2008.

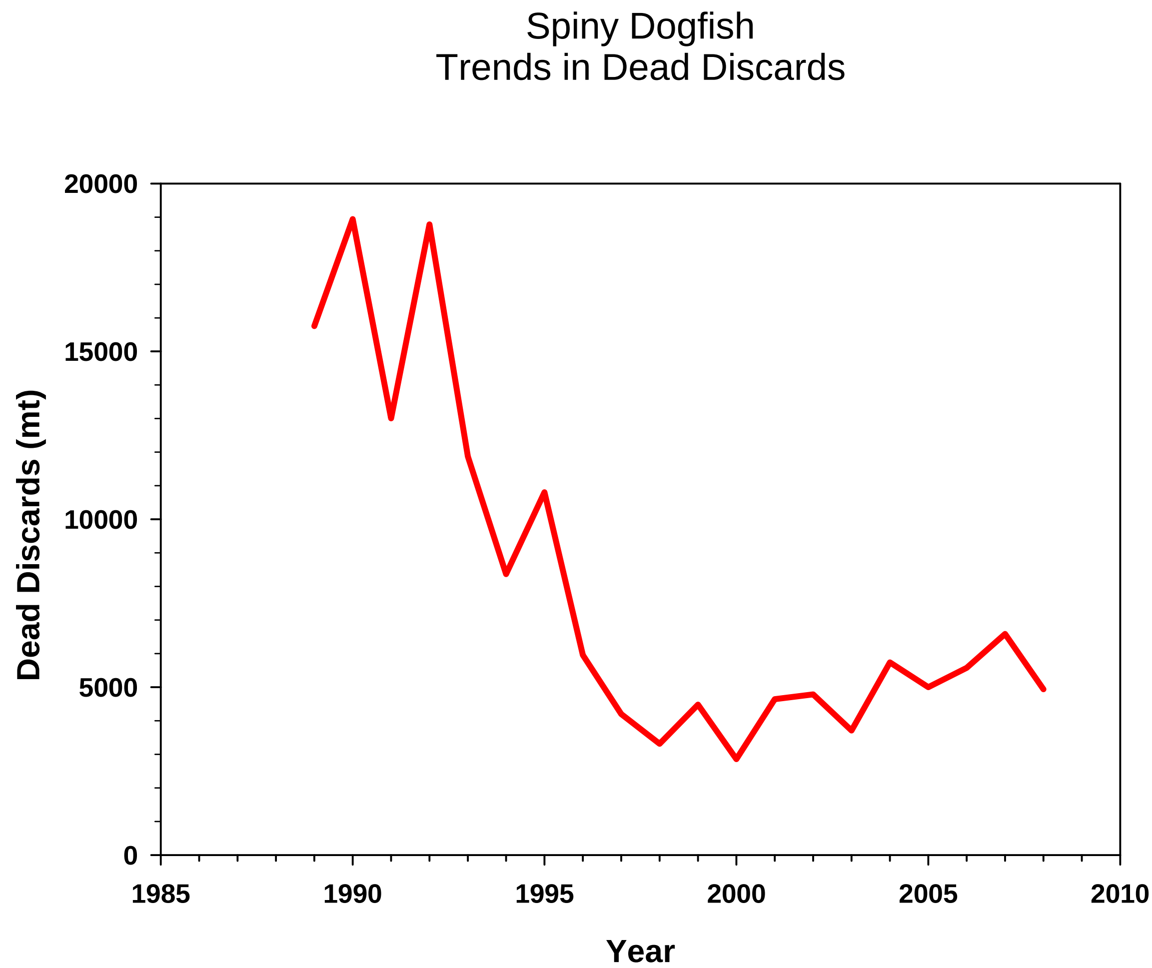


Fig. 1b. Estimated dead spiny dogfish discards (mt), 1989-2008. Discard estimates are multiplied by gear-specific mortality rates and summed over gears.

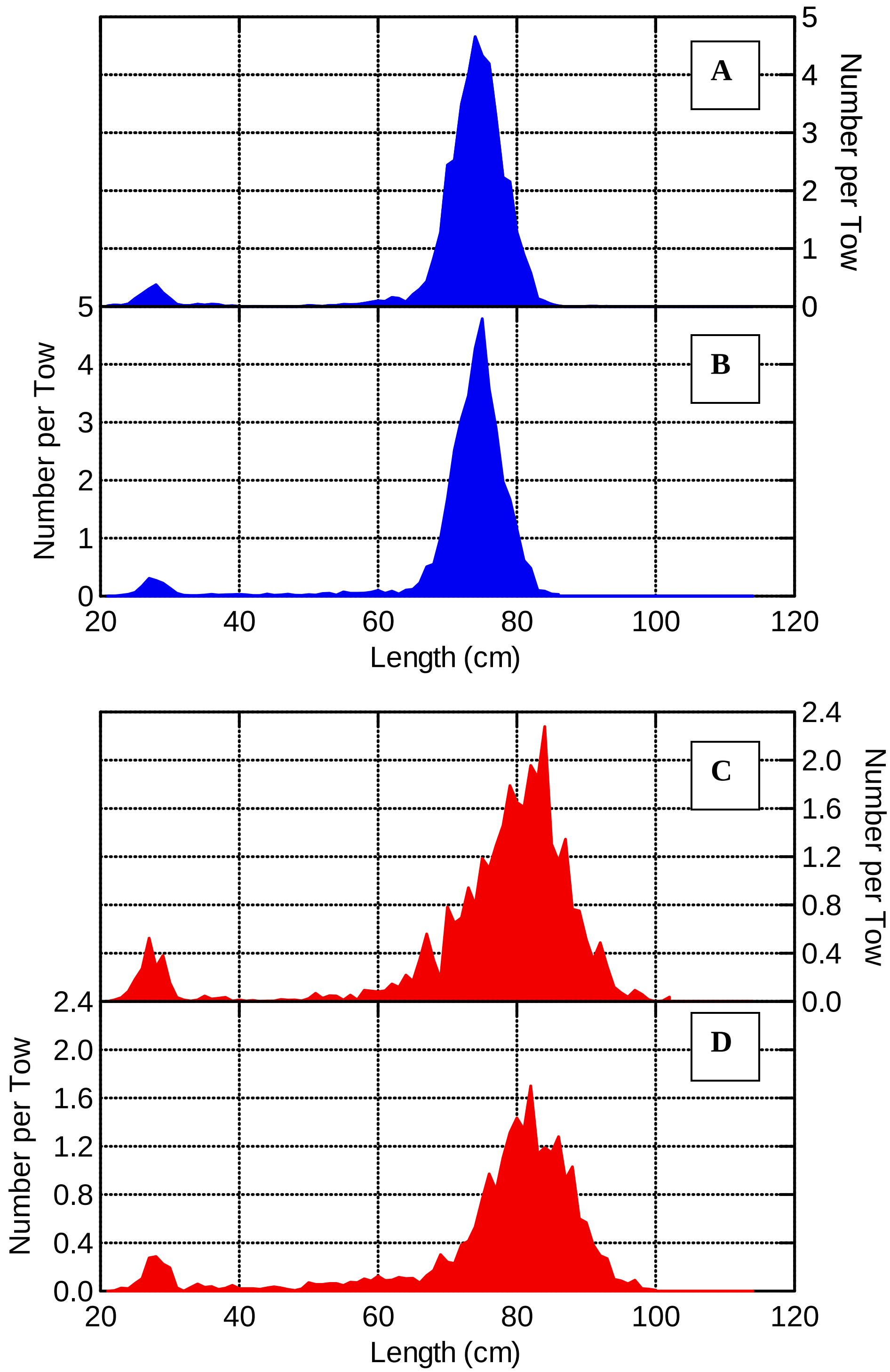


Fig 2a. Comparison of average catch per tow in spring survey during calibration experiments between FSV Bigelow with R/V Albatross in 2008. (A) Males, Bigelow, 2008, (B) Males, Albatross, 2008, (C) Females, Bigelow, 2008, (D) Females, Albatross 2008. No adjustment factor applied.

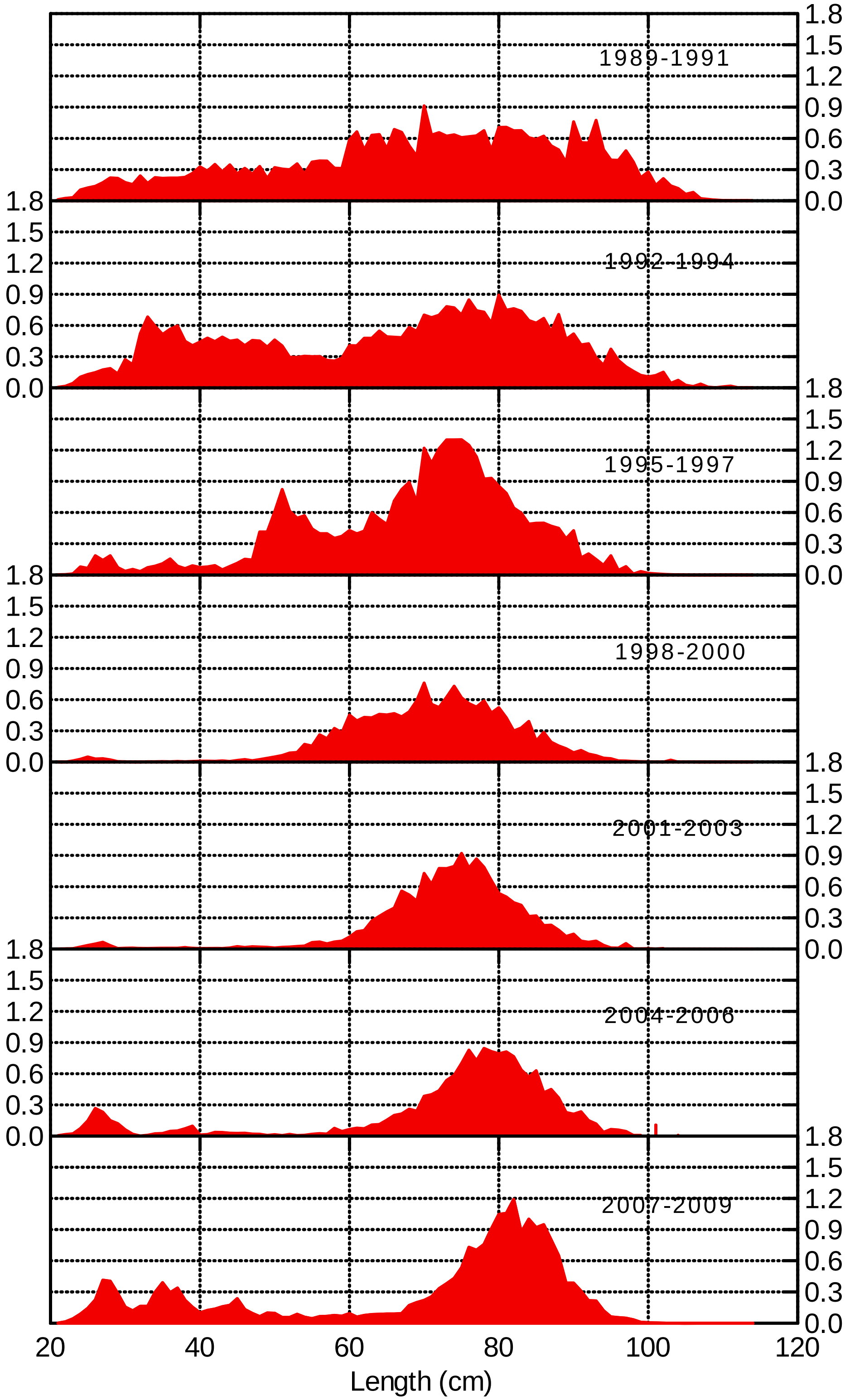


Fig. 2. **Average number of female spiny dogfish per tow by 1 cm length class in NEFSC Spring Bottom Trawl Survey by 3-yr period, 1989-2009.**

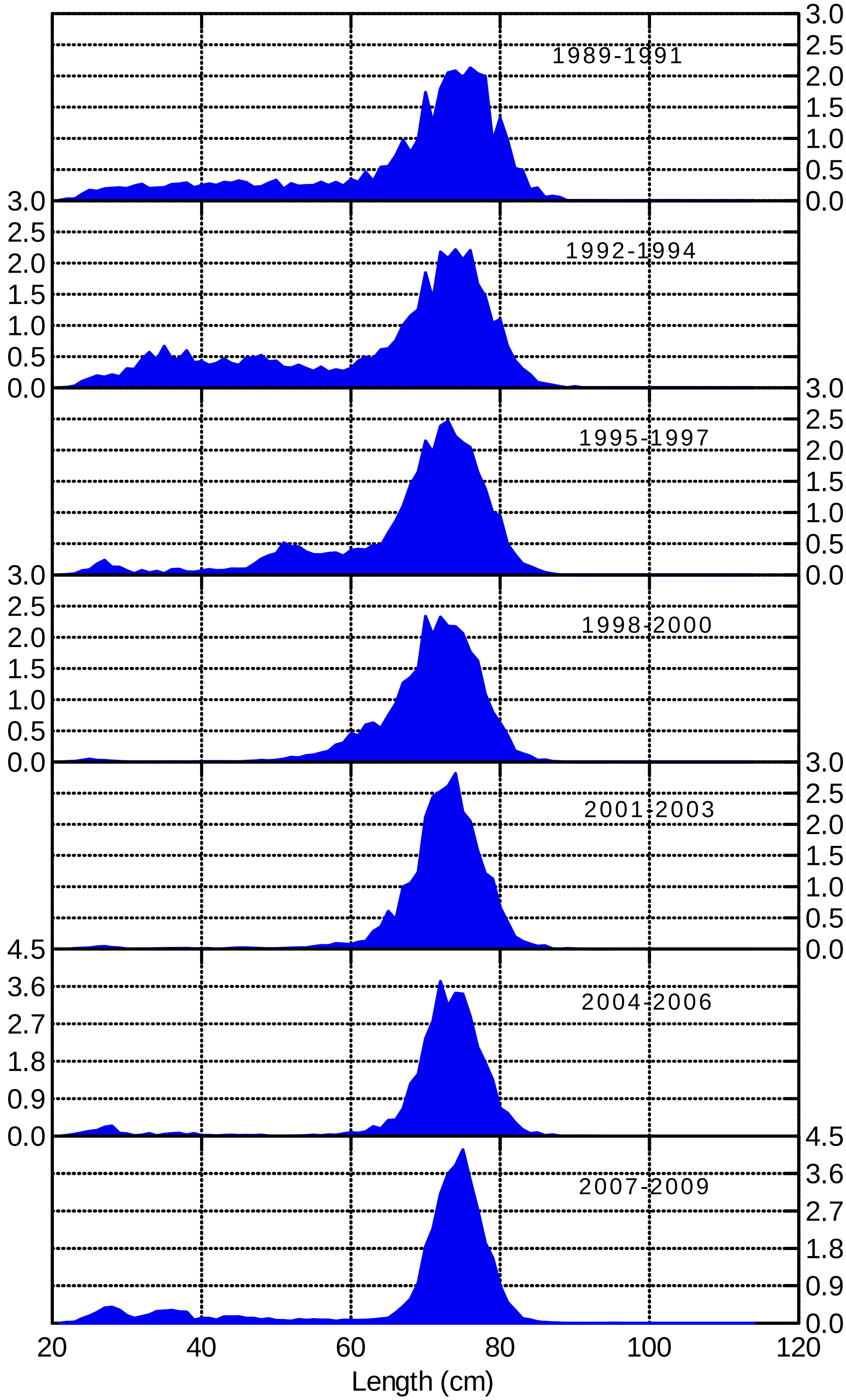
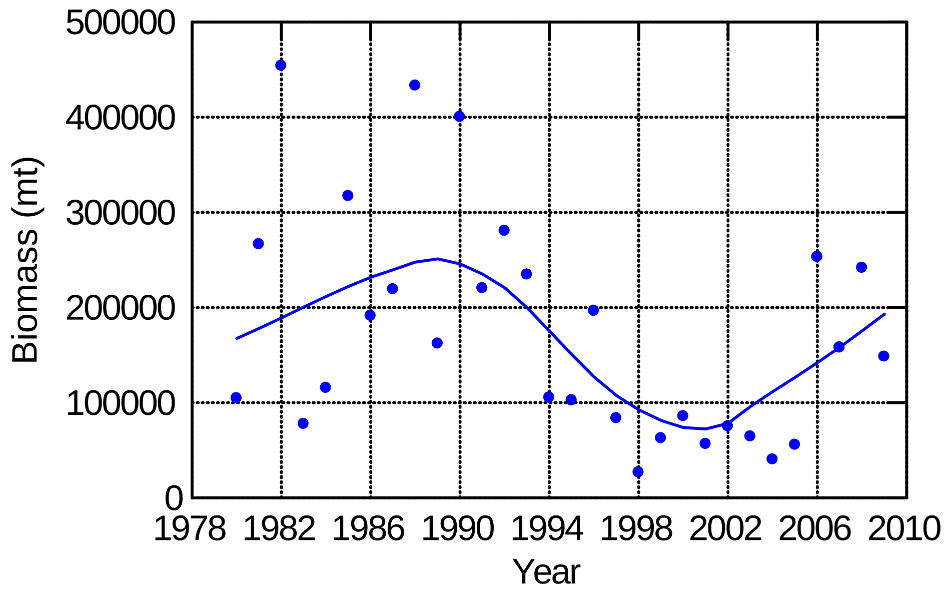


Fig. 3. **Average number of male spiny dogfish per tow by 1 cm length class in NEFSC Spring Bottom Trawl Survey by 3-yr period, 1989-2009. Note the scale change for 2004-06 and 2007-2009.**

Female Spawing Stock (>=80 cm) (mt)



Immature Female Stock (36-79 cm) (mt)

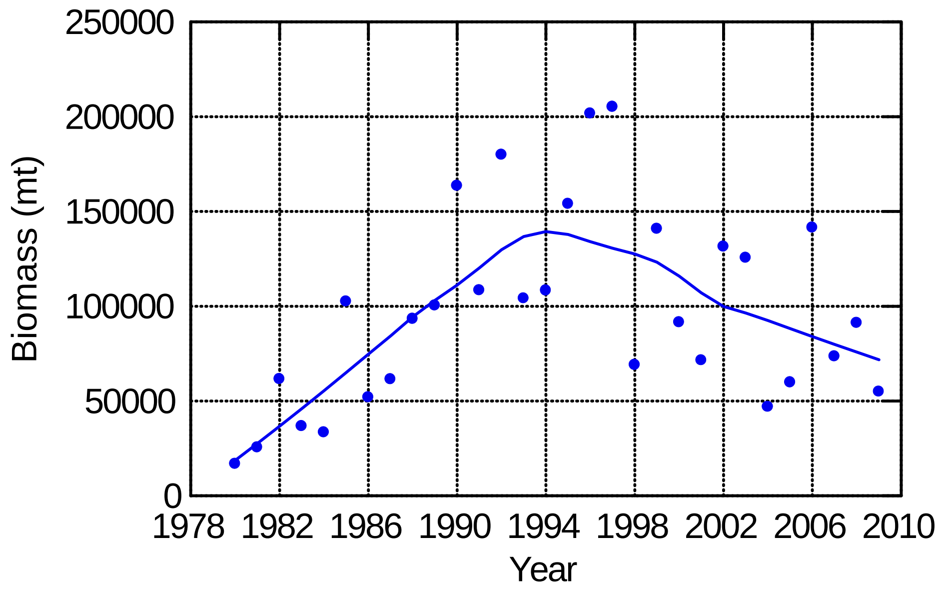


Fig. 4 **Swept area biomass of female dogfish 80 cm and greater (top) and biomass of female dogfish 36-79 cm (bottom), based on NEFSC Spring Bottom Trawl Survey, 1980-2009**.

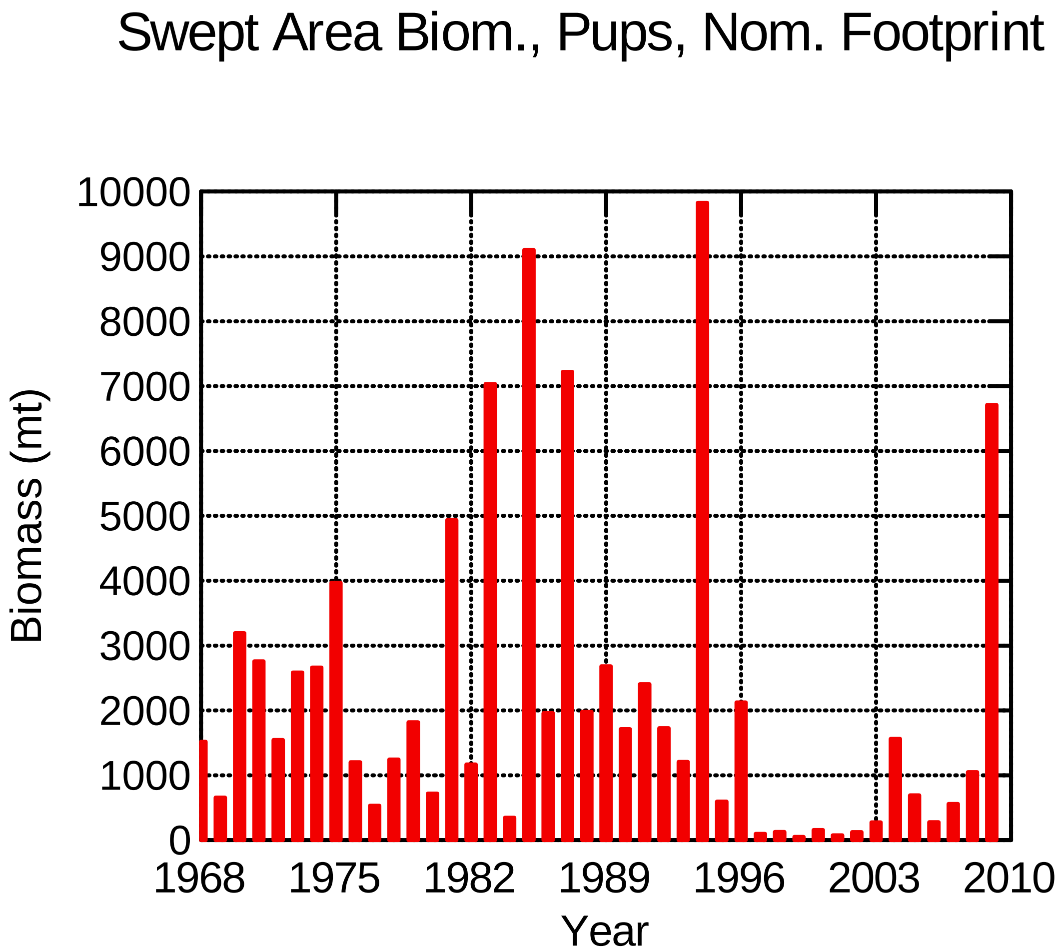
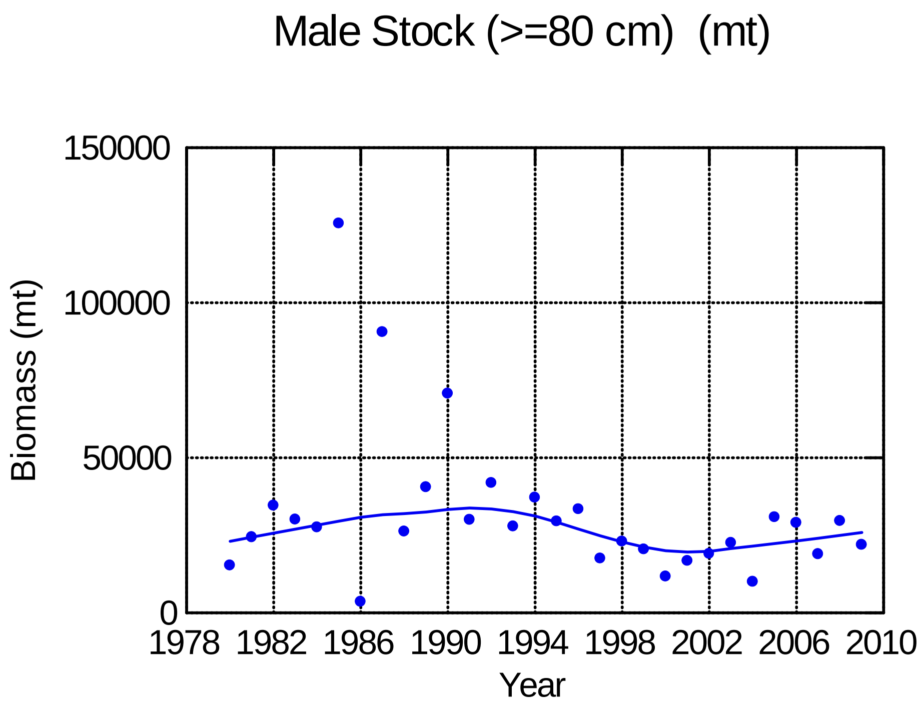


Fig. 5 **Swept area biomass of spiny dogfish recruits (< 1 yr old and < 36 cm TL), based on NEFSC Spring Bottom Trawl Survey, 1968-2009. both sexes combined.**



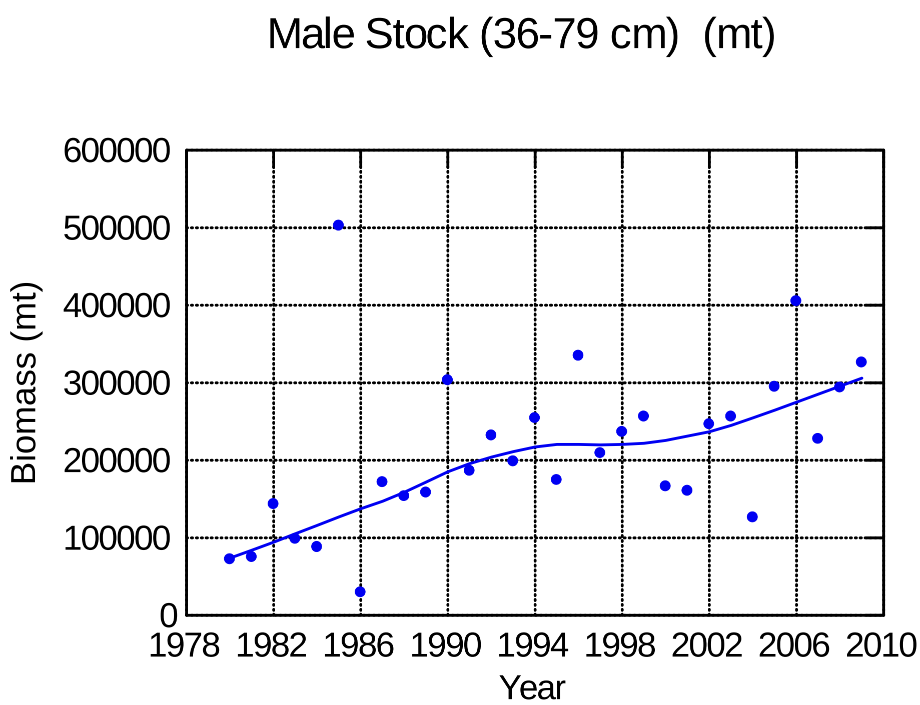


Fig. 6. **Swept area biomass of male dogfish 80 cm and greater (top) and biomass of male dogfish 36-79 cm (bottom), based on NEFSC Spring Bottom Trawl Survey, 1980-2009.**

Mature Male to Female Ratio, Spring Survey, 1980-2009

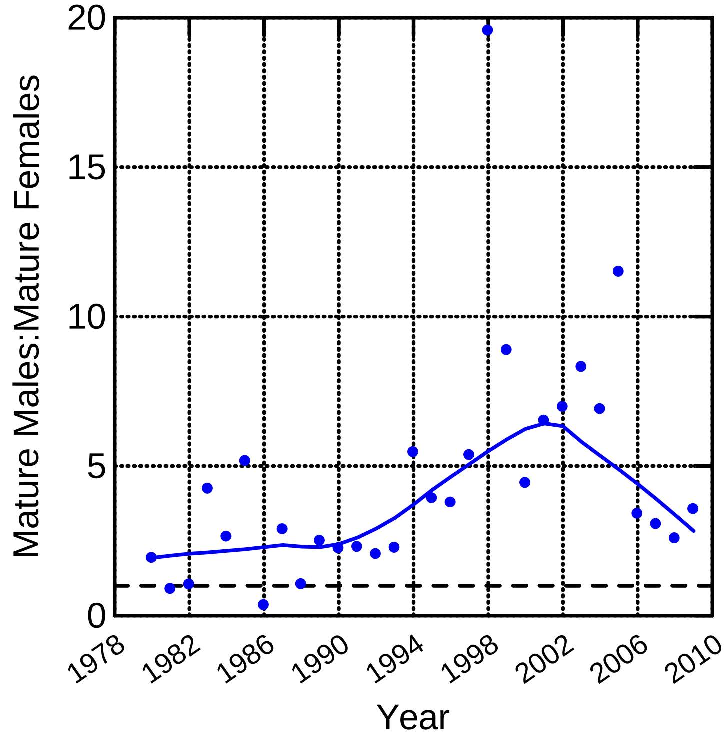
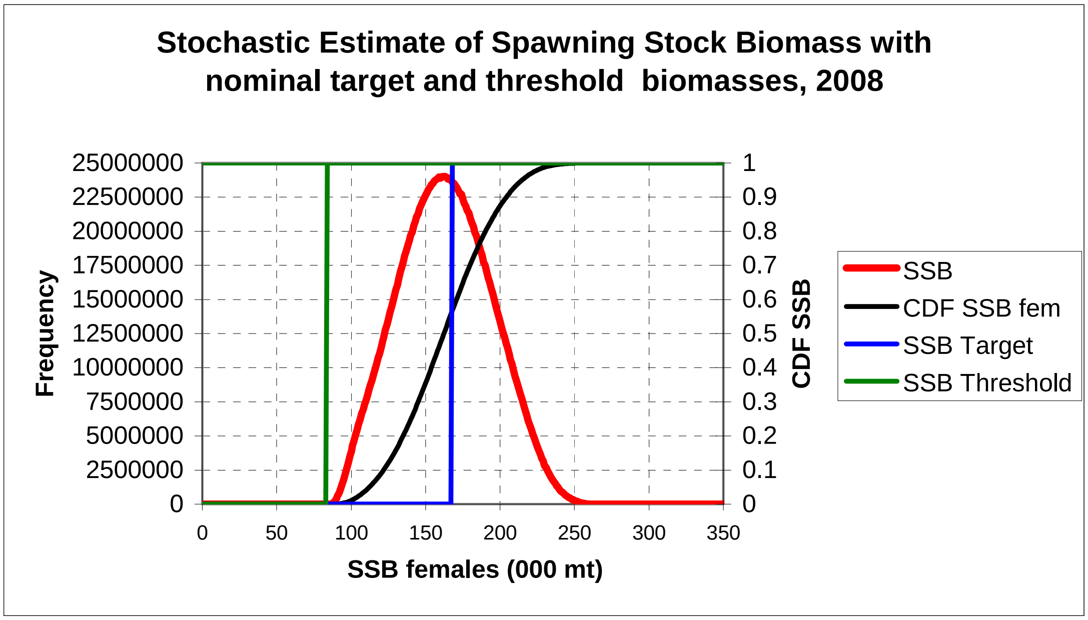


Fig. 7. Ratio of number of mature male (>60 cm) to mature female (>80 cm) spiny dogfish in NEFSC Spring Bottom Trawl Surveys, 1980-2008. Line represents LOWESS smooth with tension =0.5.



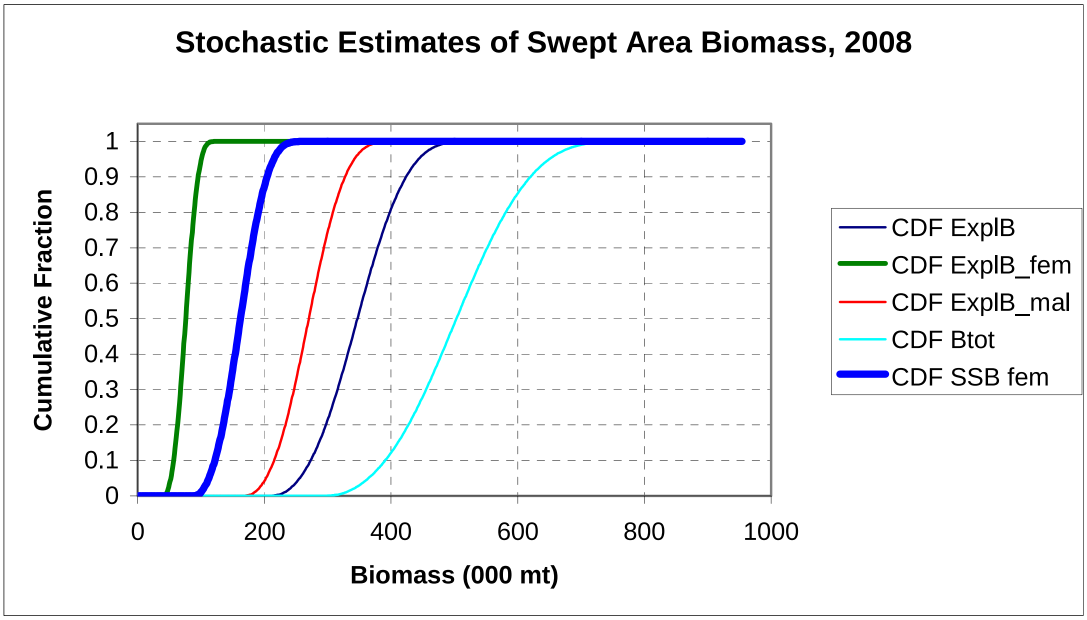
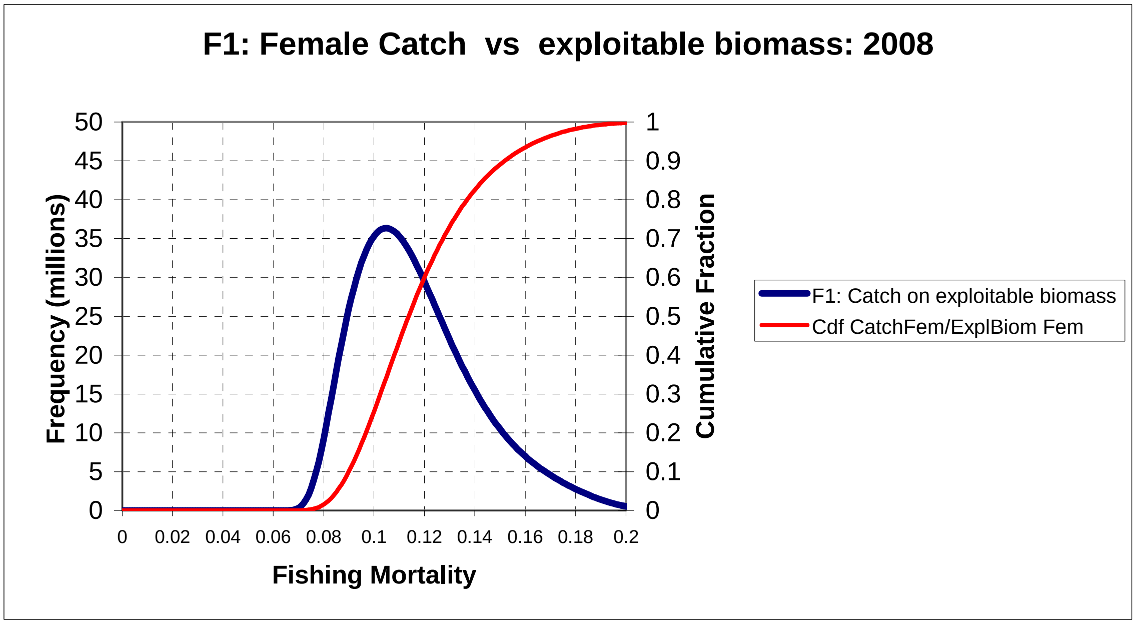


Fig 8. Estimates of female spawning stock biomass (top) and cumulative distribution functions for exploitable male and female biomass of spiny dogfish, for the 2007-2009 survey period.



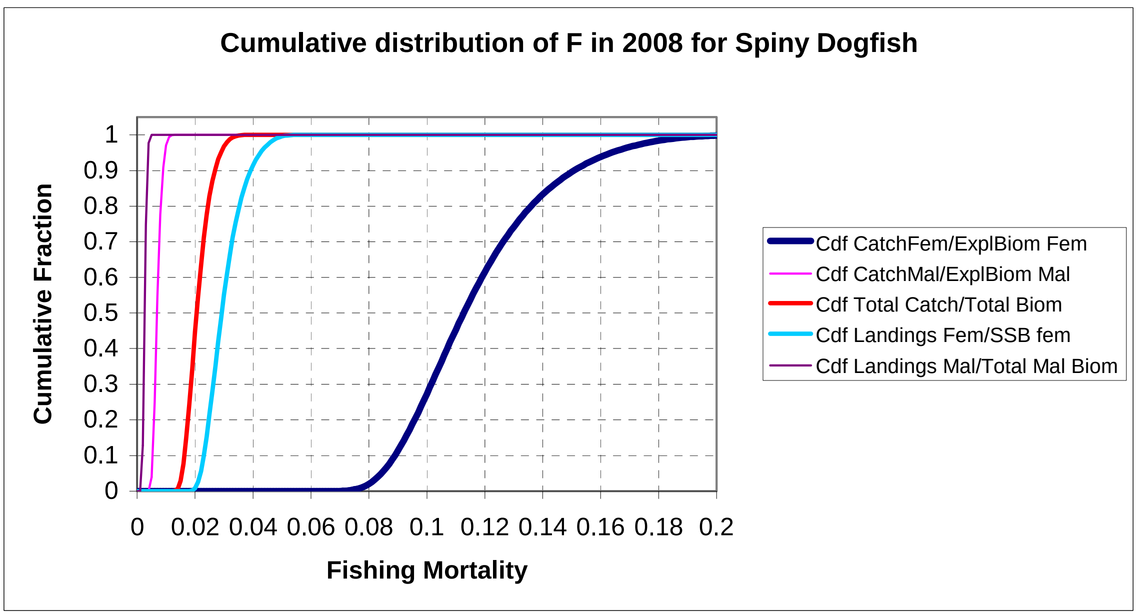


Fig. 9. Stochastic estimates of fishing mortality on spiny dogfish, 2008

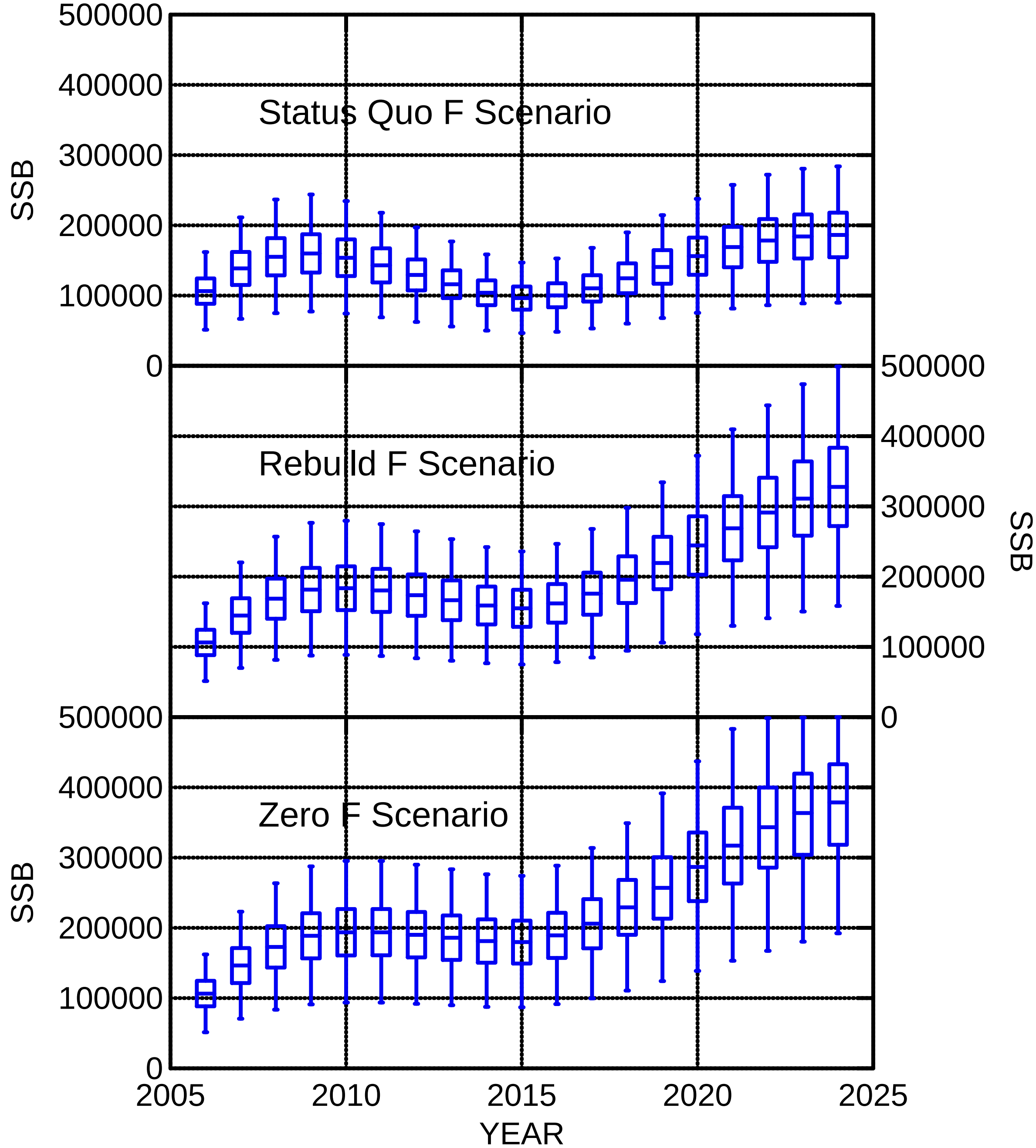


Fig. 10. **(Formerly Fig. 11. SARC 43, 2006.) Spiny dogfish spawning stock projections, 2006-2024, for three alternative scenarios: Status quo (full F=0.128), Rebuild F (0.03), and Zero F. Boxes represent interquartile ranges.**

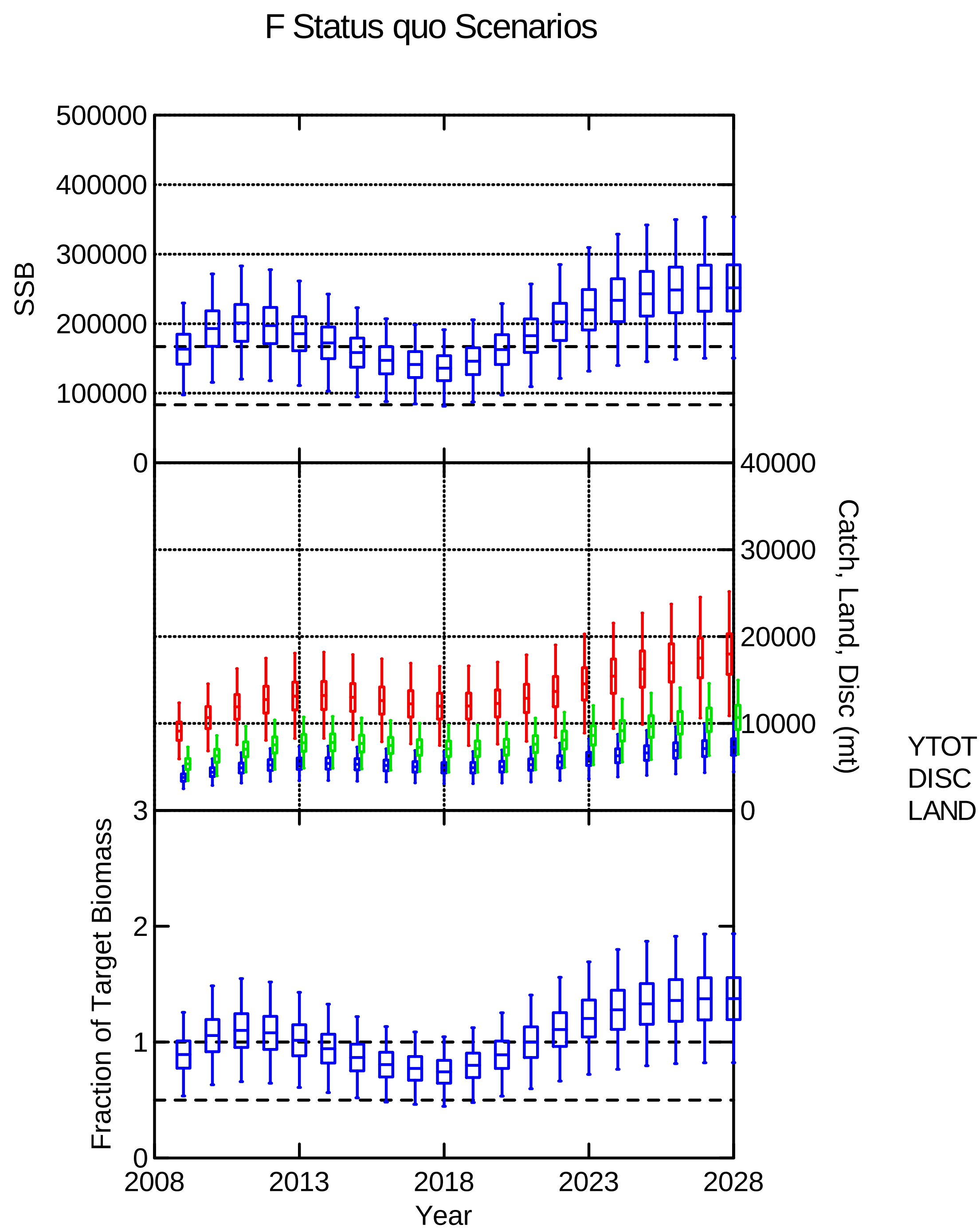


Fig 11. Predicted spawning stock biomass, catch, landings, discards, and ratio of SSB(t) to target biomass (167.8 k mt), 2009-2028 based on constant F harvest policy = F status quo. See Table 2

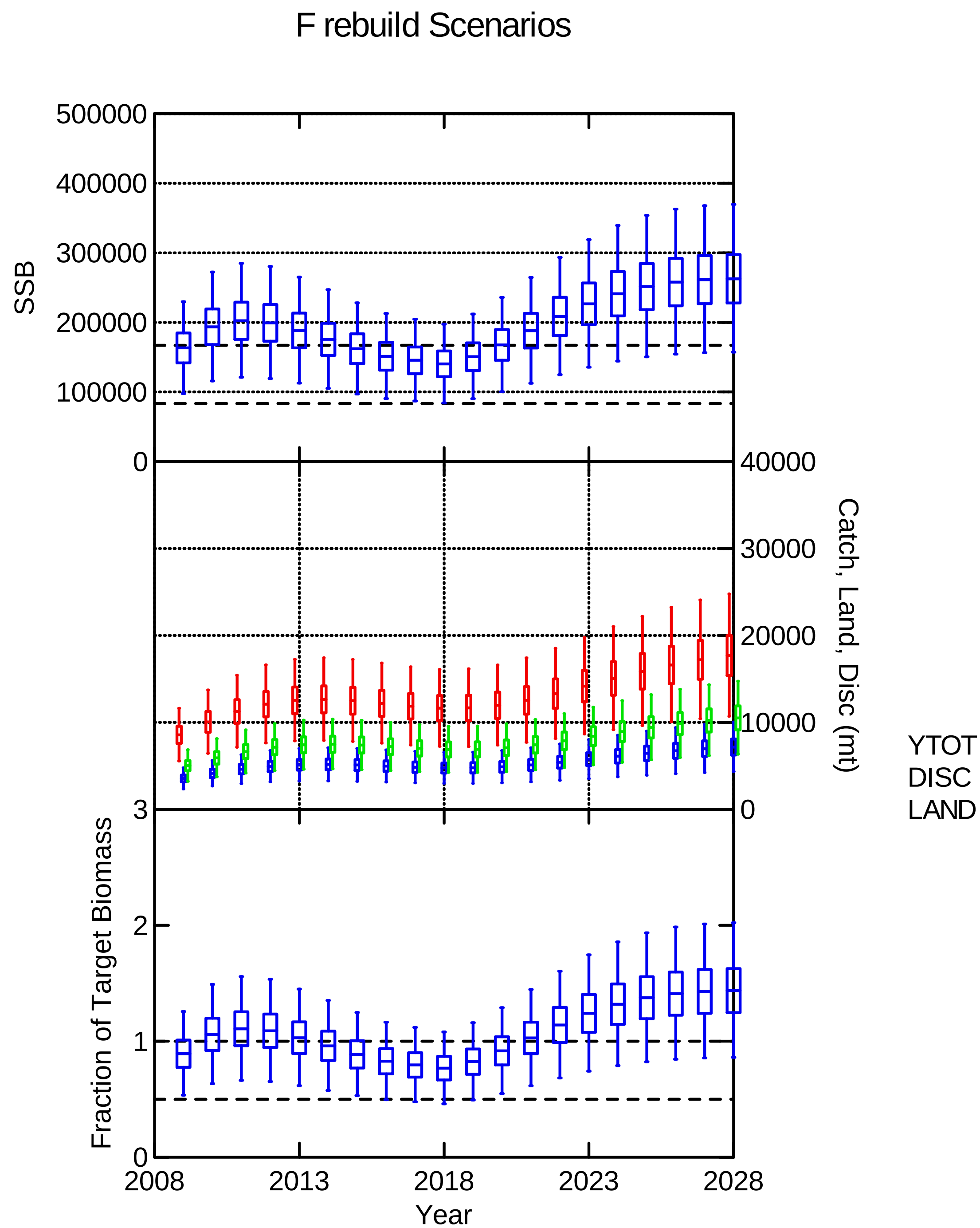


Fig 12. Predicted spawning stock biomass, catch, landings, discards, and ratio of SSB(t) to target biomass (167.8 k mt), 2009-2028 based on constant F harvest policy = F rebuild, See Table 3 .

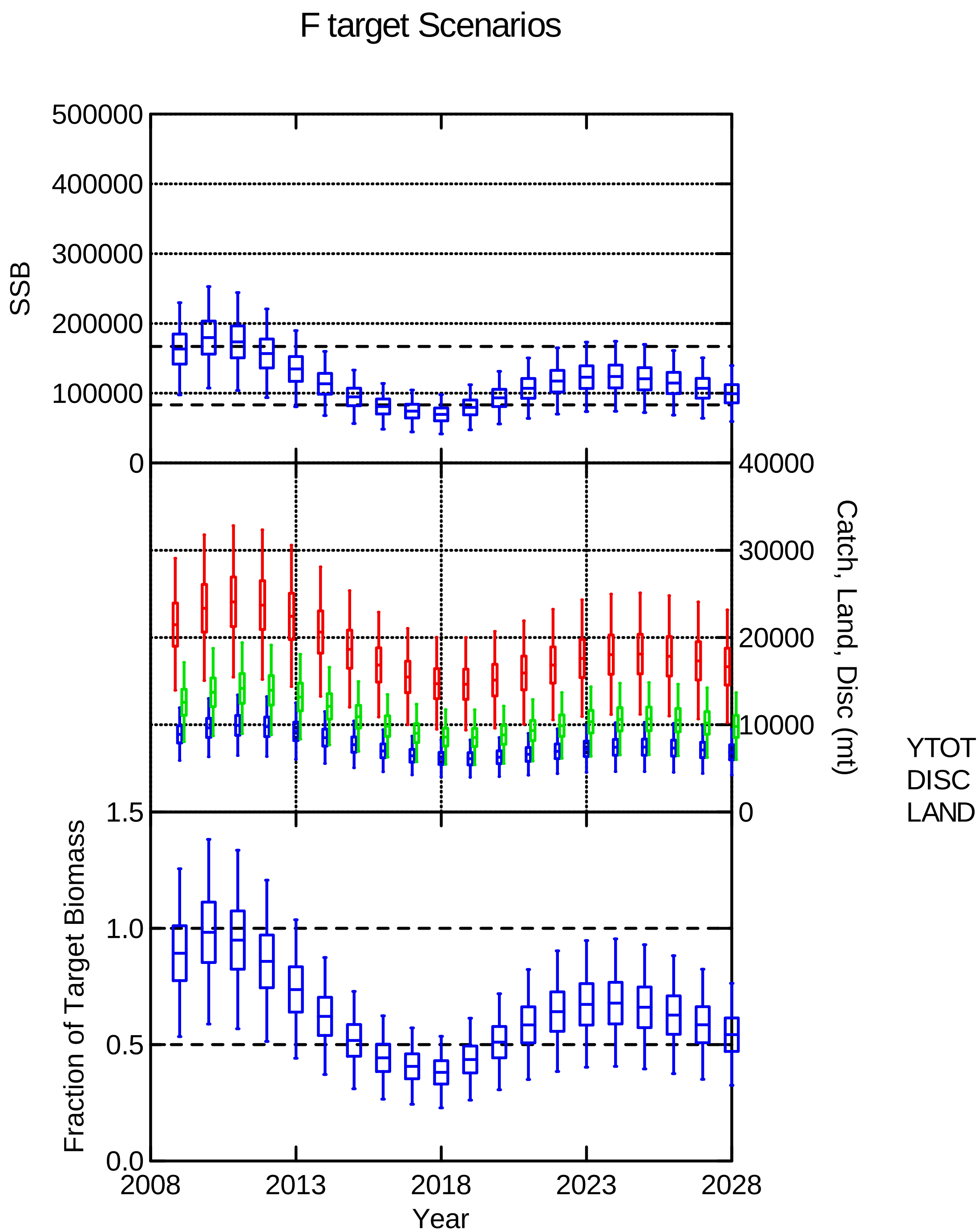


Fig 13. Predicted spawning stock biomass, catch, landings, discards, and ratio of SSB(t) to target biomass (167.8 k mt), 2009-2028 based on constant F harvest policy = Ftarget=0.284. See Table 4.

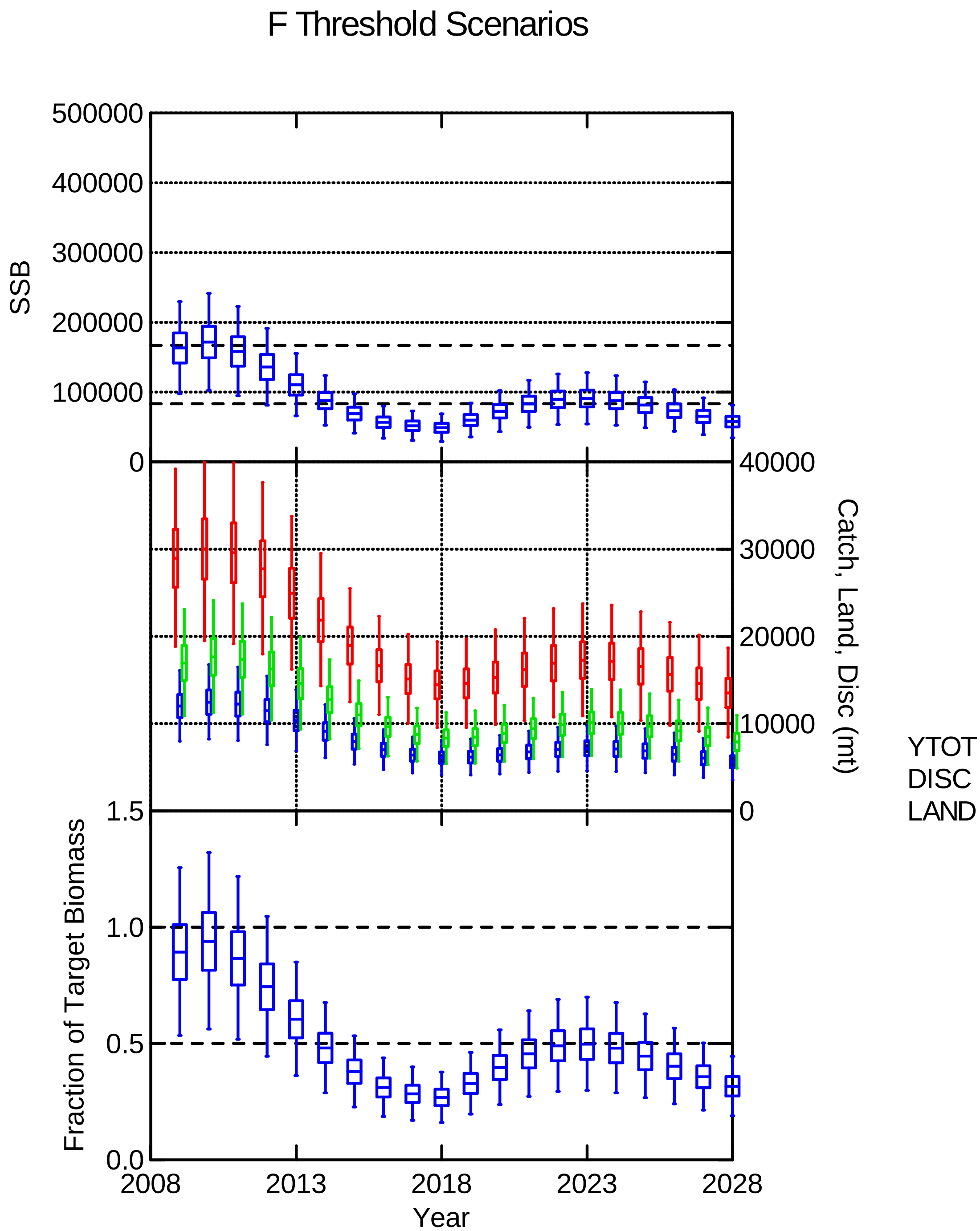


Fig 14. Predicted spawning stock biomass, catch, landings, discards, and ratio of SSB(t) to target biomass (167.8 k mt), 2009-2028 based on constant F harvest policy = Fthreshold=0.39, See Table 5.

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

	United States				
Year	Commercial	Recreational	Canada	Distant Water Fleets	Total
1962	235		0	0	235
1963	610		0	1	611
1964	730		0	16	746
1965	488		9	198	695
1966	578		39	9,389	10,006
1967	278		0	2,436	2,714
1968	158		0	4,404	4,562
1969	113		0	9,190	9,303
1970	106		19	5,640	5,765
1971	73		4	11,566	11,643
1972	69		3	23,991	24,063
1973	89		20	18,793	18,902
1974	127		36	24,513	24,676
1975	147		1	22,523	22,671
1976	550		3	16,788	17,341
1977	931		1	7,199	8,131
1978	828		84	622	1,534
1979	4,753		1,331	187	6,271
1980	4,085		660	599	5,344
1981	6,865	1,493	564	974	9,896
1982	5,411	70	389	364	6,234
1983	4,897	67		464	5,428
1984	4,450	91	2	391	4,935
1985	4,028	89	13	1,012	5,142
1986	2,748	182	20	368	3,318
1987	2,703	306	281	139	3,429
1988	3,105	359	1	647	4,112
1989	4,492	418	167	256	5,333
1990	14,731	179	1,309	393	16,611
1991	13,177	131	307	234	13,848
1992	16,858	215	868	67	18,008
1993	20,643	120	1,435	27	22,225
1994	18,798	155	1,820	2	20,774
1995	22,578	68	956	14	23,615
1996	27,136	25	431	236	27,827
1997	18,351	66	446	214	19,078
1998	20,628	39	1,055	607	22,329
1999	14,855	53	2,091	554	17,552
2000	9,257	5	2,741	402	12,405
2001	2,294	28	3,820	677	6,819
2002	2,199	205	3,584	474	6,462
2003	1,170	40	1,302	643	3,155
2004	982	105	2,362	330	3,778
2005	1,147	45	2,270	330	3,792
2006	2,249	94	2,439		4,782
2007	3,503	84	2,384		5,971
2008	4,108	214	1,572		5,894

Table 2. Estimated total discards of spiny dogfish (mt) from commercial and recreational US fisheries.
The values for otter trawl and gill net from 1981-1989 are hindcast estimates (see SARC 43)

						Assumed Discard mortality Rate				
						0.50	0.30	0.75	0.10	0.20
	Live Discards					Dead Discards				
Year	Otter Trawl	Sink Gill Net	Scallop Dredge	Line gear	Recreational	Otter Trawl	Sink Gill Net	Scallop Dredge	Line gear	Recreational
1981	36,360	5,360	na	na	296	18,180	1,608	na	na	59
1982	42,910	4,454	na	na	349	21,455	1,336	na	na	70
1983	42,188	4,042	na	na	540	21,094	1,213	na	na	108
1984	39,625	4,918	na	na	424	19,813	1,475	na	na	85
1985	33,354	4,539	na	na	964	16,677	1,362	na	na	193
1986	31,745	4,883	na	na	1,187	15,873	1,465	na	na	237
1987	29,050	4,864	na	na	1,056	14,525	1,459	na	na	211
1988	28,951	5,132	na	na	876	14,476	1,540	na	na	175
1989	28,286	5,360	na	na	1,344	14,143	1,608	na	na	269
1990	34,242	6,062	na	na	1,170	17,121	1,819	na	na	234
1991	19,322	11,030	32	97	1,350	9,661	3,309	24	10	270
1992	32,617	5,953	827	650	1,019	16,309	1,786	620	65	204
1993	17,284	9,814	209	44	1,110	8,642	2,944	157	4	222
1994	13,908	2,887	723	na	968	6,954	866	542	na	194
1995	16,997	6,731	378	na	654	8,499	2,019	284	na	131
1996	9,402	3,890	121	na	329	4,701	1,167	91	na	66
1997	6,704	2,326	198	na	837	3,352	698	149	na	167
1998	5,268	1,965	120	na	610	2,634	590	90	na	122
1999	7,685	2,005	41	na	532	3,843	602	31	na	106
2000	2,728	4,684	14	na	685	1,364	1,405	11	na	137
2001	4,919	7,204	30	na	2,099	2,460	2,161	23	na	420
2002	5,540	4,997	58	4,015	1,673	2,770	1,499	44	402	335
2003	3,853	5,413	103	2	2,987	1,927	1,624	77	0	597
2004	8,299	4,031	53	497	3,490	4,150	1,209	40	50	698
2005	7,515	3,338	15	1,175	3,509	3,758	1,001	11	118	702
2006	7,773	3,369	14	131	3,840	3,886	1,011	10	13	768
2007	8,115	5,133	61	73	4,300	4,058	1,540	45	7	860
2008	5,604	4,864	237	260	3,115	2,802	1,459	178	26	623

Table 3. Biomass estimates for spiny dogfish (thousands of metric tons) based on area swept by NEFSC trawl surveys, 1968-2009 . Estimates for 1968-2008 are based on nominal survey trawl footprint of 0.01 nm^2 for the R/V Albatross. Estimates for 2009 are based on FSV Bigelow survey adjusted to an R/V Albatross equivalent by the calibration coefficient of 1.1468. A simple 3-yr moving average is used to estimate female SSB. The biological reference point for the stock size is 200,000 mt of female SSB. See text for additional details.

Year	Lengths >= 80 cm			Lengths 36 to 79 cm			Length <= 35 cm			All Lengths	3-pt average Fem SSB
	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	104.7
1981	266.5	24.4	293.8	25.5	75.1	100.6	2.14	2.80	5.06	399.5	185.6
1982	454.0	34.6	488.6	61.6	143.3	204.9	0.48	0.69	1.17	694.6	275.1
1983	77.7	30.1	107.8	36.7	98.5	135.3	3.09	3.95	7.03	250.1	266.1
1984	115.6	27.5	143.1	33.4	88.0	121.4	0.14	0.21	0.35	264.9	215.8
1985	317.0	125.5	442.6	102.5	502.5	605.0	4.01	5.10	9.10	1056.7	170.1
1986	191.3	3.5	194.8	51.9	29.6	81.5	0.84	1.11	1.96	278.2	208.0
1987	219.1	90.5	309.6	61.5	171.7	233.1	2.46	4.76	7.22	550.0	242.5
1988	433.1	26.2	459.4	93.3	153.6	247.0	0.89	1.09	1.98	708.4	281.2
1989	162.1	40.5	202.6	100.4	158.2	258.6	1.14	1.54	2.68	463.9	271.5
1990	400.3	70.7	471.0	163.5	303.1	466.6	0.68	1.03	1.71	939.3	331.8
1991	220.4	30.0	250.3	108.4	186.3	294.7	0.98	1.43	2.41	547.4	260.9
1992	280.5	41.9	322.4	179.9	231.9	411.8	0.73	1.00	1.73	735.9	300.4
1993	234.6	27.8	262.5	104.1	198.5	302.6	0.55	0.65	1.21	566.3	245.2
1994	105.3	37.1	142.4	108.3	254.2	362.5	4.28	5.54	9.82	514.8	206.8
1995	102.4	29.5	131.9	154.0	174.5	328.5	0.25	0.35	0.59	460.9	147.5
1996	196.5	33.4	229.9	201.7	334.8	536.4	0.98	1.14	2.12	768.5	134.7
1997	83.7	17.5	101.2	205.2	209.1	414.3	0.05	0.05	0.10	515.5	127.5
1998	26.7	22.9	49.7	69.0	236.4	305.4	0.05	0.08	0.13	355.2	102.3
1999	62.7	20.4	83.1	140.8	256.4	397.2	0.02	0.03	0.05	480.4	57.7
2000	85.8	11.7	97.5	91.5	166.2	257.7	0.07	0.09	0.16	355.4	58.4
2001	56.7	16.7	73.4	71.4	160.5	231.9	0.04	0.03	0.07	305.4	68.4
2002	75.2	19.0	94.2	131.5	246.3	377.8	0.06	0.06	0.12	472.1	72.5
2003	64.5	22.5	87.1	125.5	256.3	381.8	0.13	0.14	0.27	469.1	65.5
2004	40.4	10.0	50.3	46.9	126.2	173.1	0.66	0.91	1.56	225.0	60.0
2005	55.8	30.8	86.6	59.8	294.7	354.5	0.28	0.42	0.69	441.9	53.6
2006	253.4	29.0	282.5	141.6	406.5	548.1	0.10	0.17	0.27	830.8	116.6
2007	158.0	18.9	176.9	73.6	227.6	301.1	0.23	0.32	0.56	478.6	155.8
2008	241.7	29.6	271.4	91.2	293.7	385.0	0.47	0.59	1.05	657.4	217.7
2009*	***148.3***	***21.9***	***170.2***	***54.9***	***326.1***	***381.0***	***2.95***	***3.76***	***6.71***	***557.9***	***182.7***

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

Data 2009 have been adjusted to AL IV equivalents using preliminary HB Bigelow calibration coefficients.

Table 4. Summary of stochastic projections for spiny dogfish under a constant F harvest strategy equal to F2008_status quo=0.117 for 2009 to 2038. Table entries are means of predicted values

Scenario = FstatusQuo

	Average												
Year	F on females	F on males	SSB (mt)	Total Catch (mt)	Total Landing (mt)	Female Landings (mt)	Male Landings (mt)	Total Discards (mt)	Female Discards (mt)	Male Discards (mt)	SSB(t)/ SSB_target	Probabilty (SSB>SSB_target)	Probabilty (SSB> SSB_thresh)
2009	0.117	0.003	163,304	9,127	5,347	4,794	553	3,780	3,188	592	0.893	0.27	1
2010	0.117	0.003	193,139	10,678	6,282	5,742	540	4,396	3,818	578	1.056	0.606	1.000
2011	0.117	0.003	201,208	11,911	7,026	6,501	525	4,885	4,323	562	1.100	0.678	1.000
2012	0.117	0.003	197,419	12,750	7,534	7,024	510	5,216	4,671	546	1.080	0.646	1.000
2013	0.117	0.003	185,783	13,156	7,780	7,282	498	5,375	4,842	533	1.016	0.532	1.000
2014	0.117	0.003	172,485	13,224	7,823	7,332	491	5,401	4,875	526	0.943	0.380	1.000
2015	0.117	0.003	158,513	13,006	7,693	7,206	487	5,313	4,792	521	0.867	0.216	1.000
2016	0.117	0.003	147,304	12,639	7,473	6,988	485	5,166	4,646	519	0.806	0.104	0.994
2017	0.117	0.003	141,317	12,258	7,245	6,763	482	5,013	4,497	516	0.773	0.056	0.984
2018	0.117	0.003	136,043	11,998	7,090	6,612	478	4,908	4,397	512	0.744	0.026	0.970
2019	0.117	0.003	146,184	12,010	7,098	6,625	473	4,912	4,405	506	0.799	0.094	0.992
2020	0.117	0.003	162,840	12,312	7,281	6,813	468	5,031	4,530	501	0.890	0.264	1.000
2021	0.117	0.003	182,812	12,890	7,630	7,167	463	5,261	4,765	496	1.000	0.498	1.000
2022	0.117	0.003	202,722	13,677	8,103	7,645	458	5,574	5,083	490	1.109	0.690	1.000
2023	0.117	0.003	220,128	14,564	8,637	8,184	454	5,927	5,441	486	1.204	0.808	1.000
2024	0.117	0.003	233,791	15,449	9,170	8,719	450	6,280	5,797	482	1.278	0.872	1.000
2025	0.117	0.003	243,141	16,263	9,659	9,209	449	6,604	6,124	481	1.330	0.904	1.000
2026	0.117	0.003	248,662	16,978	10,088	9,638	450	6,890	6,408	482	1.360	0.920	1.000
2027	0.117	0.003	251,185	17,547	10,429	9,975	454	7,118	6,633	486	1.374	0.926	1.000
2028	0.117	0.003	251,568	17,992	10,694	10,234	460	7,297	6,805	492	1.376	0.928	1.000
2029	0.117	0.003	251,983	18,353	10,909	10,441	468	7,444	6,943	501	1.378	0.928	1.000
2030	0.117	0.003	253,967	18,686	11,107	10,630	477	7,579	7,068	511	1.389	0.932	1.000
2031	0.117	0.003	258,808	19,049	11,323	10,835	488	7,727	7,204	522	1.415	0.944	1.000
2032	0.117	0.003	266,741	19,490	11,585	11,085	499	7,905	7,371	534	1.459	0.958	1.000
2033	0.117	0.003	277,724	20,039	11,911	11,401	511	8,127	7,581	547	1.519	0.974	1.000
2034	0.117	0.003	290,976	20,704	12,308	11,786	522	8,396	7,837	559	1.591	0.988	1.000
2035	0.117	0.003	305,709	21,481	12,772	12,238	534	8,709	8,137	572	1.672	1.000	1.000
2036	0.117	0.003	320,845	22,340	13,285	12,738	546	9,055	8,470	585	1.755	1.000	1.000
2037	0.117	0.003	335,525	23,250	13,828	13,269	559	9,422	8,823	599	1.835	1.000	1.000
2038	0.117	0.003	349,039	24,179	14,383	13,810	573	9,796	9,183	613	1.909	1.000	1.000
Average	0.117	0.003	225,029	15,933	9,450	8,956	494	6,484	5,955	528	1.231	0.671	0.998
Ave '09-18	0.117	0.003	169,651	12,075	7,129	6,624	505	4,945	4,405	541	0.928	0.351	0.995
Ave '19-28	0.117	0.003	214,303	14,968	8,879	8,421	458	6,089	5,599	490	0.000	0.000	0.000
Ave '29-38	0.117	0.003	291,132	20,757	12,341	11,823	518	8,416	7,862	554	0.000	0.000	0.000
Formula	*A*	*B*	*C*	*D=E+H*	*E=F+G*	*F*	*G*	*H=I+J*	*I*	*J*	*K*	*L*	*M*

Table 5. Summary of stochastic projections for spiny dogfish under a constant F harvest strategy equal to Frebuild=0.11 for 2009 to 2038. Table entries are means of predicted values.

Scenario = Frebuild

Year	F on females	F on males	SSB (mt)	Total Catch (mt)	Total Landing (mt)	Female Landings (mt)	Male Landings (mt)	Total Discards (mt)	Female Discards (mt)	Male Discards (mt)	SSB(t)/ SSB_target	Probabilty (SSB>SSB_target)	Probabilty (SSB> SSB_thresh)
	Average												
2009	0.110	0.003	163,304	8,575	5,024	4,505	519	3,551	2,995	556	0.893	0.27	1
2010	0.110	0.003	193,745	10,064	5,921	5,414	507	4,143	3,600	543	1.059	0.612	1.000
2011	0.110	0.003	202,507	11,266	6,647	6,154	493	4,619	4,092	528	1.107	0.688	1.000
2012	0.110	0.003	199,417	12,105	7,154	6,675	479	4,951	4,439	512	1.091	0.662	1.000
2013	0.110	0.003	188,426	12,540	7,418	6,950	468	5,122	4,621	501	1.030	0.558	1.000
2014	0.110	0.003	175,695	12,658	7,490	7,029	461	5,168	4,674	494	0.961	0.418	1.000
2015	0.110	0.003	162,180	12,500	7,396	6,939	458	5,104	4,614	490	0.887	0.258	1.000
2016	0.110	0.003	151,317	12,193	7,212	6,756	456	4,981	4,492	488	0.827	0.140	1.000
2017	0.110	0.003	145,582	11,864	7,015	6,562	453	4,849	4,363	485	0.796	0.088	0.990
2018	0.110	0.003	140,472	11,641	6,883	6,432	450	4,759	4,277	482	0.768	0.052	0.982
2019	0.110	0.003	150,775	11,670	6,901	6,455	446	4,770	4,292	478	0.825	0.134	0.998
2020	0.110	0.003	167,709	11,973	7,083	6,642	442	4,889	4,416	473	0.917	0.322	1.000
2021	0.110	0.003	188,116	12,539	7,424	6,987	438	5,114	4,646	469	1.029	0.556	1.000
2022	0.110	0.003	208,630	13,307	7,887	7,454	434	5,420	4,956	464	1.141	0.736	1.000
2023	0.110	0.003	226,790	14,180	8,412	7,982	430	5,768	5,307	460	1.240	0.842	1.000
2024	0.110	0.003	241,315	15,058	8,940	8,513	428	6,118	5,660	458	1.320	0.898	1.000
2025	0.110	0.003	251,587	15,877	9,432	9,005	427	6,445	5,987	457	1.376	0.928	1.000
2026	0.110	0.003	258,052	16,609	9,871	9,443	429	6,738	6,279	459	1.411	0.942	1.000
2027	0.110	0.003	261,503	17,208	10,230	9,797	433	6,978	6,514	463	1.430	0.948	1.000
2028	0.110	0.003	262,774	17,690	10,518	10,079	439	7,172	6,702	470	1.437	0.952	1.000
2029	0.110	0.003	264,029	18,095	10,759	10,312	448	7,336	6,856	479	1.444	0.954	1.000
2030	0.110	0.003	266,818	18,473	10,984	10,526	458	7,489	6,999	490	1.459	0.958	1.000
2031	0.110	0.003	272,457	18,878	11,225	10,756	469	7,653	7,152	502	1.490	0.968	1.000
2032	0.110	0.003	281,221	19,356	11,509	11,029	480	7,847	7,333	514	1.538	0.978	1.000
2033	0.110	0.003	293,115	19,938	11,855	11,363	492	8,082	7,555	527	1.603	0.990	1.000
2034	0.110	0.003	307,386	20,633	12,270	11,765	505	8,363	7,823	540	1.681	1.000	1.000
2035	0.110	0.003	323,269	21,437	12,750	12,233	517	8,687	8,134	553	1.768	1.000	1.000
2036	0.110	0.003	339,686	22,326	13,280	12,751	530	9,045	8,478	567	1.858	1.000	1.000
2037	0.110	0.003	355,764	23,269	13,844	13,301	543	9,425	8,844	582	1.945	1.000	1.000
2038	0.110	0.003	370,771	24,238	14,422	13,865	558	9,816	9,219	597	2.028	1.000	1.000
Average	0.110	0.003	233,814	15,605	9,259	8,789	470	6,347	5,844	503	1.279	0.695	0.999
Ave '09-18	0.110	0.003	172,264	11,541	6,816	6,342	474	4,725	4,217	508	0.942	0.375	0.997
Ave '19-28	0.110	0.003	221,725	14,611	8,670	8,236	434	5,941	5,476	465	0.000	0.000	0.000
Ave '29-38	0.110	0.003	307,452	20,664	12,290	11,790	500	8,374	7,839	535	0.000	0.000	0.000
Formula	*A*	*B*	*C*	*D=E+H*	*E=F+G*	*F*	*G*	*H=I+J*	*I*	*J*	*K*	*L*	*M*

Table 6. Summary of stochastic projections for spiny dogfish under a constant F harvest strategy equal to Ftarget=0.284 for 2009 to 2038. Table entries are means of predicted values

Scenario = Ftarget

	Average												
Year	F on females	F on males	SSB (mt)	Total Catch (mt)	Total Landing (mt)	Female Landings (mt)	Male Landings (mt)	Total Discards (mt)	Female Discards (mt)	Male Discards (mt)	SSB(t)/ SSB_target	Probabilty (SSB>SSB_target)	Probabilty (SSB> SSB_thresh)
2009	0.284	0.008	163,304	21,480	12,576	11,239	1,337	8,904	7,473	1,431	0.893	0.27	1
2010	0.284	0.008	179,737	23,365	13,717	12,417	1,300	9,648	8,257	1,391	0.983	0.464	1.000
2011	0.284	0.008	173,660	24,096	14,166	12,908	1,258	9,930	8,583	1,347	0.950	0.394	1.000
2012	0.284	0.008	156,948	23,724	13,953	12,737	1,216	9,771	8,469	1,302	0.858	0.198	1.000
2013	0.284	0.008	134,806	22,430	13,184	12,000	1,183	9,246	7,979	1,267	0.737	0.020	0.968
2014	0.284	0.008	113,655	20,633	12,111	10,952	1,159	8,522	7,282	1,240	0.622	0.000	0.854
2015	0.284	0.008	94,757	18,656	10,928	9,789	1,139	7,728	6,509	1,219	0.518	0.000	0.590
2016	0.284	0.008	81,084	16,860	9,854	8,733	1,121	7,006	5,807	1,200	0.443	0.000	0.278
2017	0.284	0.008	74,342	15,492	9,038	7,941	1,097	6,454	5,280	1,174	0.407	0.000	0.130
2018	0.284	0.008	69,660	14,718	8,580	7,512	1,068	6,138	4,995	1,143	0.381	0.000	0.054
2019	0.284	0.008	79,756	14,648	8,546	7,511	1,035	6,102	4,994	1,108	0.436	0.000	0.246
2020	0.284	0.008	93,433	15,120	8,838	7,838	1,000	6,282	5,211	1,071	0.511	0.000	0.564
2021	0.284	0.008	106,995	15,942	9,340	8,375	965	6,602	5,569	1,033	0.585	0.000	0.786
2022	0.284	0.008	117,412	16,854	9,896	8,966	930	6,957	5,962	996	0.642	0.000	0.884
2023	0.284	0.008	123,118	17,601	10,353	9,457	897	7,248	6,288	960	0.673	0.000	0.920
2024	0.284	0.008	124,061	18,038	10,623	9,756	866	7,415	6,487	928	0.678	0.000	0.926
2025	0.284	0.008	120,809	18,110	10,673	9,832	841	7,437	6,537	900	0.661	0.000	0.908
2026	0.284	0.008	114,687	17,858	10,526	9,707	820	7,332	6,454	877	0.627	0.000	0.864
2027	0.284	0.008	107,134	17,331	10,214	9,411	803	7,117	6,258	860	0.586	0.000	0.788
2028	0.284	0.008	99,289	16,663	9,816	9,026	790	6,847	6,002	846	0.543	0.000	0.674
2029	0.284	0.008	93,102	15,994	9,417	8,638	779	6,577	5,743	834	0.509	0.000	0.556
2030	0.284	0.008	89,497	15,441	9,087	8,318	769	6,354	5,531	823	0.489	0.000	0.478
2031	0.284	0.008	88,901	15,083	8,874	8,116	759	6,209	5,396	812	0.486	0.000	0.464
2032	0.284	0.008	90,650	14,942	8,792	8,044	748	6,150	5,349	801	0.496	0.000	0.504
2033	0.284	0.008	93,959	14,993	8,826	8,089	737	6,167	5,379	789	0.514	0.000	0.574
2034	0.284	0.008	97,707	15,175	8,938	8,213	725	6,237	5,461	776	0.534	0.000	0.646
2035	0.284	0.008	101,025	15,410	9,082	8,370	712	6,328	5,565	762	0.552	0.000	0.702
2036	0.284	0.008	103,209	15,623	9,213	8,513	700	6,410	5,660	749	0.564	0.000	0.736
2037	0.284	0.008	103,907	15,757	9,296	8,607	689	6,461	5,723	738	0.568	0.000	0.746
2038	0.284	0.008	103,059	15,778	9,311	8,632	679	6,467	5,740	727	0.564	0.000	0.734
Average	0.284	0.008	109,789	17,460	10,259	9,322	937	7,202	6,198	1,003	0.600	0.045	0.686
Ave '09-18	0.284	0.008	124,195	20,145	11,811	10,623	1,188	8,335	7,063	1,271	0.679	0.135	0.687
Ave '19-28	0.284	0.008	108,669	16,816	9,883	8,988	895	6,934	5,976	958	0.000	0.000	0.000
Ave '29-38	0.284	0.008	96,502	15,420	9,084	8,354	730	6,336	5,555	781	0.000	0.000	0.000
Formula	*A*	*B*	*C*	*D=E+H*	*E=F+G*	*F*	*G*	*H=I+J*	*I*	*J*	*K*	*L*	*M*

Table 7. Summary of stochastic projections for spiny dogfish under a constant F harvest strategy equal to Fthreshold=0.39 for 2009 to 2038. Table entries are means of predicted values.

Scenario = Fthreshold

	Average												
Year	F on females	F on males	SSB (mt)	Total Catch (mt)	Total Landing (mt)	Female Landings (mt)	Male Landings (mt)	Total Discards (mt)	Female Discards (mt)	Male Discards (mt)	SSB(t)/ SSB_target	Probabilty (SSB>SSB_target)	Probabilty (SSB> SSB_thresh)
2009	0.390	0.010	163,304	28,969	16,953	15,119	1,833	12,016	10,053	1,963	0.893	0.27	1
2010	0.390	0.010	171,754	30,121	17,659	15,881	1,777	12,463	10,560	1,903	0.939	0.370	1.000
2011	0.390	0.010	158,336	29,620	17,373	15,657	1,716	12,247	10,411	1,837	0.866	0.214	1.000
2012	0.390	0.010	136,038	27,752	16,266	14,612	1,654	11,486	9,716	1,770	0.744	0.026	0.970
2013	0.390	0.010	110,505	24,950	14,595	12,991	1,605	10,355	8,638	1,718	0.604	0.000	0.824
2014	0.390	0.010	87,921	21,864	12,751	11,186	1,565	9,113	7,438	1,675	0.481	0.000	0.442
2015	0.390	0.010	69,269	18,961	11,015	9,485	1,530	7,945	6,307	1,638	0.379	0.000	0.048
2016	0.390	0.010	56,899	16,645	9,633	8,138	1,495	7,012	5,411	1,601	0.311	0.000	0.000
2017	0.390	0.010	51,864	15,117	8,726	7,275	1,451	6,391	4,837	1,553	0.284	0.000	0.000
2018	0.390	0.010	49,013	14,446	8,336	6,937	1,399	6,110	4,612	1,498	0.268	0.000	0.000
2019	0.390	0.010	59,980	14,615	8,451	7,109	1,342	6,163	4,727	1,436	0.328	0.000	0.000
2020	0.390	0.010	72,566	15,298	8,876	7,594	1,282	6,422	5,049	1,372	0.397	0.000	0.098
2021	0.390	0.010	83,252	16,182	9,422	8,200	1,222	6,761	5,452	1,309	0.455	0.000	0.330
2022	0.390	0.010	89,636	16,928	9,884	8,720	1,164	7,044	5,798	1,246	0.490	0.000	0.480
2023	0.390	0.010	90,951	17,277	10,107	8,998	1,109	7,170	5,983	1,187	0.497	0.000	0.510
2024	0.390	0.010	87,880	17,143	10,039	8,980	1,059	7,104	5,971	1,133	0.481	0.000	0.440
2025	0.390	0.010	81,546	16,563	9,701	8,686	1,015	6,862	5,775	1,087	0.446	0.000	0.288
2026	0.390	0.010	73,524	15,667	9,172	8,195	977	6,495	5,449	1,046	0.402	0.000	0.114
2027	0.390	0.010	65,282	14,593	8,535	7,590	945	6,058	5,047	1,011	0.357	0.000	0.008
2028	0.390	0.010	57,790	13,523	7,899	6,983	916	5,624	4,643	981	0.316	0.000	0.000
2029	0.390	0.010	52,587	12,610	7,357	6,467	890	5,253	4,300	952	0.288	0.000	0.000
2030	0.390	0.010	50,074	11,946	6,965	6,101	864	4,981	4,057	925	0.274	0.000	0.000
2031	0.390	0.010	50,159	11,562	6,740	5,903	837	4,821	3,925	896	0.274	0.000	0.000
2032	0.390	0.010	51,851	11,418	6,661	5,850	810	4,758	3,890	868	0.284	0.000	0.000
2033	0.390	0.010	54,222	11,434	6,677	5,894	783	4,757	3,919	838	0.297	0.000	0.000
2034	0.390	0.010	56,275	11,509	6,729	5,973	755	4,780	3,972	809	0.308	0.000	0.000
2035	0.390	0.010	57,387	11,550	6,760	6,032	728	4,790	4,011	780	0.314	0.000	0.000
2036	0.390	0.010	57,211	11,492	6,731	6,029	703	4,761	4,009	752	0.313	0.000	0.000
2037	0.390	0.010	55,740	11,303	6,623	5,945	679	4,679	3,953	727	0.305	0.000	0.000
2038	0.390	0.010	53,196	10,984	6,438	5,781	657	4,547	3,844	703	0.291	0.000	0.000
Average	0.390	0.010	78,534	16,735	9,769	8,610	1,159	6,966	5,725	1,240	0.429	0.029	0.252
Ave '09-18	0.390	0.010	105,490	22,844	13,331	11,728	1,603	9,514	7,798	1,715	0.577	0.088	0.528
Ave '19-28	0.390	0.010	76,241	15,779	9,209	8,105	1,103	6,570	5,389	1,181	0.000	0.000	0.000
Ave '29-38	0.390	0.010	53,870	11,581	6,768	5,998	771	4,813	3,988	825	0.000	0.000	0.000
Formula	*A*	*B*	*C*	*D=E+H*	*E=F+G*	*F*	*G*	*H=I+J*	*I*	*J*	*K*	*L*	*M*

Appendix 1. Approximate upper bound on efficiency of R/V Albatross for capturing spiny dogfish derived from comparison of capture rates with the FSV Bigelow.

An inter-vessel calibration experiment attempts to relate the average catchability of vessel A to vessel B by comparing paired tow catch rates over a variety of habitats, bottom types and species densities. If we conveniently let subscript A refer to the Albatross and B refer to the Bigelow, then the expected index catch rate I can be expressed as

$$I_A = e_A a_A D$$
$$I_B = e_B a_B D$$

Where ***e*** represents efficiency, ***a*** is the average area swept and D is the true density. The ratio of the index catches can be used to compute a calibration coefficient γ expressed as the ratio of I_B to I_A.

$$\frac{I_B}{I_A} = \gamma = \frac{e_B a_B D}{e_A a_A D} = \frac{e_B a_B}{e_A a_A}$$

The estimate area swept per tow can be expressed as a function of the distance between the wings of the new or as a function of the distance between the doors. The latter distance is important for schooling species like dogfish that herd between the sand clouds created by the trawl doors. The nominal areas swept by the Bigelow and Albatross nets are provided below.

Parameter	***Albatross***	***Bigelow***
Tow speeds(knots)	3.8	3
Tow duration (min)	33	20
Door width (ft)	68.6	104.9867
Wing width(ft)	35.93	39.37
Door Swept area ft ^2	871140.4	637899
Wing Swept area ft^2	456269.3	239212.1

Plugging the swept areas into the equation for γ gives:

$$\gamma = 1.1468 = \frac{e_B a_B}{e_A a_A} = \frac{e_B \, 637{,}899}{e_A \, 871{,}140}$$

$$\frac{e_A}{e_B} = 0.6385$$

If the Bigelow net were 100% efficient for spiny dogfish between the doors then the maximum possible Albatross efficiency would be 64%.

Science, Service, Stewardship

Update on the Status of Spiny Dogfish in 2009 and Initial Evaluation of Alternative Harvest Strategies

November 4, 2009

Paul Rago and Katherine Sosebee
Northeast Fisheries Science Center
National Marine Fisheries Service

For
Mid Atlantic Fishery Management Council
Science and Statistical Committee
October 27, 2009

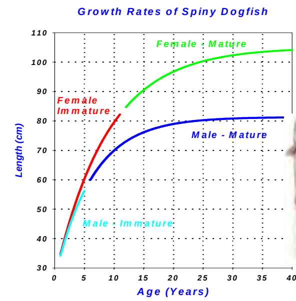
NOAA FISHERIES SERVICE

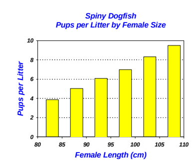
Objectives

- Assessment update of spiny dogfish in 2009
  - Landings and Discards in 2008
  - Survey Results including calibration of FSV Bigelow to Albatross
- Estimates of Biomass and Fishing Mortality
- Biological Reference Points
- Projections and Uncertainty

Quick Overview

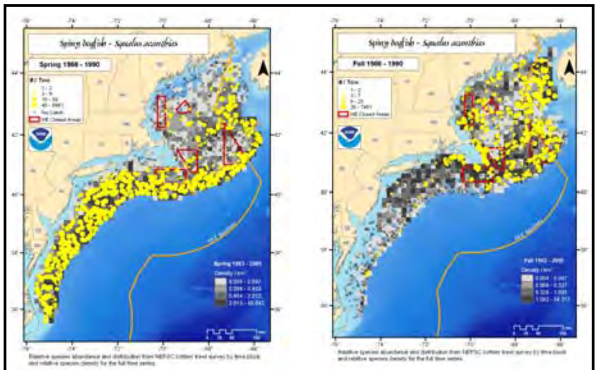
- Dogfish abundance remains at high levels consistent with last 4 years
- Evidence of strong recruitment in 2009.
- Discards are about equal to total landings but have been declining for last 4 years
- All projections suggest population biomass will oscillate as the recruitment deficit is paid back.
- Population should continue to increase for about 5 years, then begin to decline.
- Magnitude of oscillation can be damped by magnitude of F



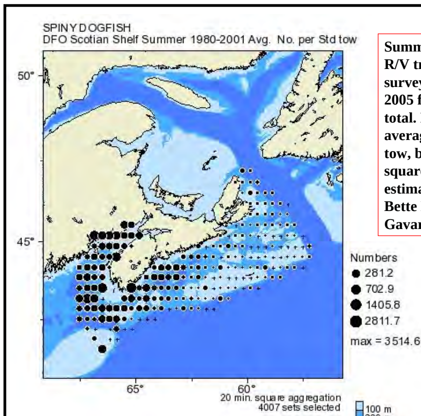


The Basics

- Long lived ... 50 to 100 yrs.
- Grow Slowly...Males 80 cm, Females 105 cm
- Mature Late ...Male 6-11 yr,Females 12-21 yr
- Long gestation...22 month,
- Large size at birth ~25-30 cm
- Low fecundity...2-10 pups



Comparison of typical Spring and Fall NEFSC bottom trawl survey distributions, 1986-1990. Shaded 10 minute squares represent long-term relative density per km². "x" represents zero tows.



Summary of DFO Canadian R/V trawl survey swept area survey estimates (mt), 1980-2005 for males, females and total. Map data express average densities per standard tow, binned at a 20 minute square aggregation. Survey estimates provide courtesy of Bette Hatt and Stratis Gavaris, DFO.

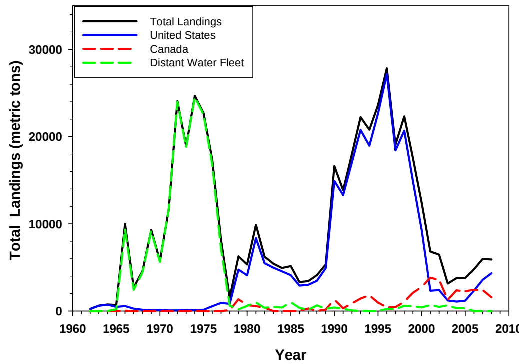


Figure 1a. Total landings of spiny dogfish by US, Canadian and foreign fleets in NAFO Statistical Areas 2-6, 1962-2008.

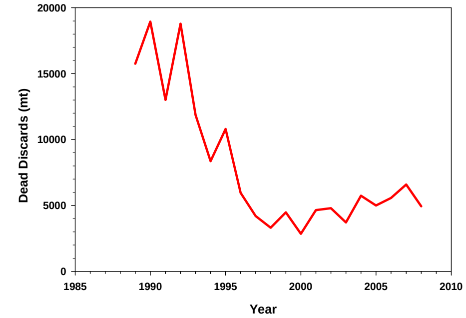
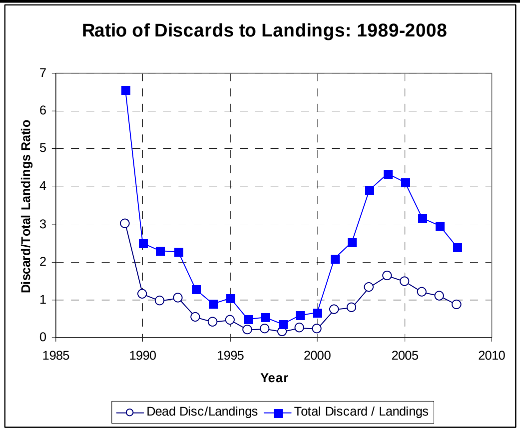


Fig. 1b. Estimated dead spiny dogfish discards (mt), 1989-2008. Discard estimates are multiplied by gear-specific mortality rates and summed over gears.

Discard Mortality Factors

- Gill nets
  - Previous SARC—75% mortality
  - This assessment: 30% per Rulifson experiments
- Trawls
  - Previous SARC—50%
  - This assessment—same
- Hook and Line Commercial
  - Previous —25%
  - This assessment—10% per Mandelman and others
- Recreational
  - Previous assessment—100%
  - This assessment—20% per comparisons with other recr fish.



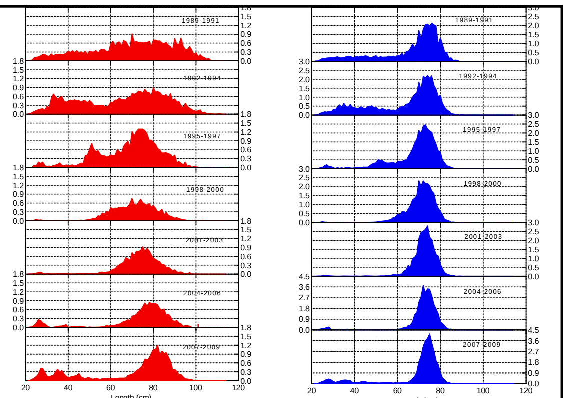
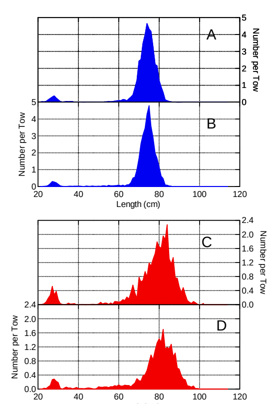
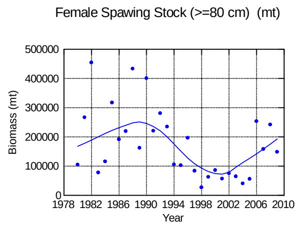


Fig. 3. **Average number of female (left) and male (right) spiny dogfish per tow by 1 cm length class in NEFSC Spring Bottom Trawl Survey by 3-yr period, 1989-2009. Note the scale change for 2004-06 and 2007-2009 for male dogfish**



Comparison of size frequency distributions for male and female spiny dogfish.

Fig 2a. Comparison of average catch per tow in spring survey during calibration experiments between FSV Bigelow with R/V Albatross in 2008. (A) Males, Bigelow, 2008, (B) Males, Albatross, 2008, (C) Females, Bigelow, 2008, (D) Females, Albatross 2008. No adjustment factor applied.



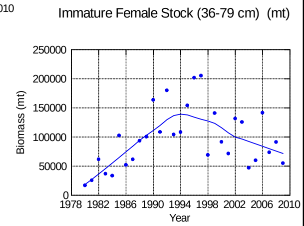


Fig. 4 **Swept area biomass of female dogfish 80 cm and greater (top) and biomass of female dogfish 36-79 cm (bottom), based on NEFSC Spring Bottom Trawl Survey, 1980-2009**.

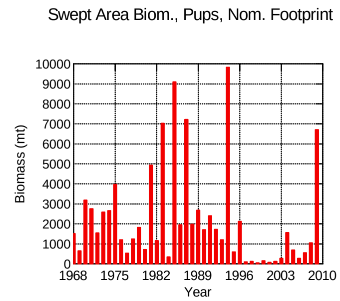
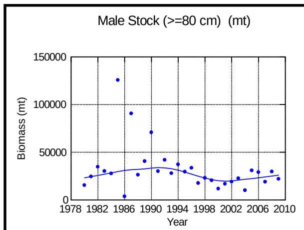


Fig. 5 **Swept area biomass of spiny dogfish recruits (< 1 yr old and < 36 cm TL), based on NEFSC Spring Bottom Trawl Survey, 1968-2009. both sexes combined.**



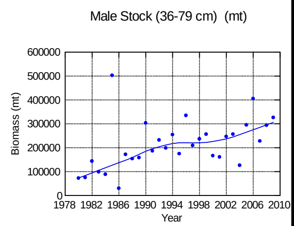


Fig. 6. **Swept area biomass of male dogfish 80 cm and greater (top) and biomass of male dogfish 36-79 cm (bottom), based on NEFSC Spring Bottom Trawl Survey, 1980-2009.**

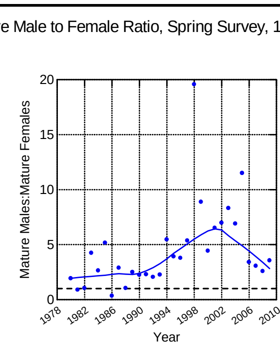


Fig. 7. Ratio of number of mature male (>60 cm) to mature female (>80 cm) spiny dogfish in NEFSC Spring Bottom Trawl Surveys, 1980-2008. Line represents LOWESS smooth with tension =0.5.

Swept Area Biomass Estimates

- The swept area biomass estimate of spiny dogfish in the 2009 NEFSC spring bottom trawl survey was 557,900 mt.
- The three-year moving average in 2009 was lower than the three-year average for 2008 largely due to lower estimate of mature female spawning stock (Table 3).
- Variations in swept area abundance estimates between years reflect both sampling variability and availability within the survey area.
- The three-year moving average of female SSB fell from 218 k mt to 183.7 k mt. These swept area estimates are based on the nominal footprint of 0.01 nm^2. The 2009 estimate is below the biological reference point of 200,000 mt based on this same nominal footprint.

Year	Lengths >= 80 cm			Lengths 36 to 79 cm			Length <= 35 cm			All Lengths	3-pt average Fem SSB
	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	104.7
1981	266.5	24.4	293.8	25.5	75.1	100.6	2.14	2.80	5.06	399.5	185.6
1982	454.0	34.6	488.6	61.6	143.3	204.9	0.48	0.69	1.17	694.6	275.1
1983	77.7	30.1	107.8	36.7	98.5	135.3	3.09	3.95	7.03	250.1	266.1
1984	115.6	27.5	143.1	33.4	88.0	121.4	0.14	0.21	0.35	264.9	215.8
1985	317.0	125.5	442.6	102.5	502.5	605.0	4.01	5.10	9.10	1056.7	170.1
1986	191.3	3.5	194.8	51.9	29.6	81.5	0.84	1.11	1.96	278.2	208.0
1987	219.1	90.5	309.6	61.5	171.7	233.1	2.46	4.76	7.22	550.0	242.5
1988	433.1	26.2	459.4	93.3	153.6	247.0	0.89	1.09	1.98	708.4	281.2
1989	162.1	40.5	202.6	100.4	158.2	258.6	1.14	1.54	2.68	463.9	271.5
1990	400.3	70.7	471.0	163.5	303.1	466.6	0.68	1.03	1.71	939.3	331.8
1991	220.4	30.0	250.3	108.4	186.3	294.7	0.98	1.43	2.41	547.4	260.9
1992	280.5	41.9	322.4	179.9	231.9	411.8	0.73	1.00	1.73	735.9	300.4
1993	234.6	27.8	262.5	104.1	198.5	302.6	0.55	0.65	1.21	566.3	245.2
1994	105.3	37.1	142.4	108.3	254.2	362.5	4.28	5.54	9.82	514.8	206.8
1995	102.4	29.5	131.9	154.0	174.5	328.5	0.25	0.35	0.59	460.9	147.5
1996	196.5	33.4	229.9	201.7	334.8	536.4	0.98	1.14	2.12	768.5	134.7
1997	83.7	17.5	101.2	205.2	209.1	414.3	0.05	0.05	0.10	515.5	127.5
1998	26.7	22.9	49.7	69.0	236.4	305.4	0.05	0.08	0.13	355.2	102.3
1999	62.7	20.4	83.1	140.8	256.4	397.2	0.02	0.03	0.05	480.4	57.7
2000	85.8	11.7	97.5	91.5	166.2	257.7	0.07	0.09	0.16	355.4	58.4
2001	56.7	16.7	73.4	71.4	160.5	231.9	0.04	0.03	0.07	305.4	68.4
2002	75.2	19.0	94.2	131.5	246.3	377.8	0.06	0.06	0.12	472.1	72.5
2003	64.5	22.5	87.1	125.5	256.3	381.8	0.13	0.14	0.27	469.1	65.5
2004	40.4	10.0	50.3	46.9	126.2	173.1	0.66	0.91	1.56	225.0	60.0
2005	55.8	30.8	86.6	59.8	294.7	354.5	0.28	0.42	0.69	441.9	53.6
2006	253.4	29.0	282.5	141.6	406.5	548.1	0.10	0.17	0.27	830.8	116.6
2007	158.0	18.9	176.9	73.6	227.6	301.1	0.23	0.32	0.56	478.6	155.8
2008	241.7	29.6	271.4	91.2	293.7	385.0	0.47	0.59	1.05	657.4	217.7
2009*	***148.3***	***21.9***	***170.2***	***54.9***	***326.1***	***381.0***	***2.95***	***3.76***	***6.71***	***557.9***	***182.7***

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

Data 2009 have been adjusted to AL IV equivalents using preliminary HB Bigelow calibration coefficients.

Table 3. Biomass estimates for spiny dogfish (thousands of metric tons) based on area swept by NEFSC trawl surveys, 1968-2009 . Estimates for 1968-2008 are based on nominal survey trawl footprint of 0.01 nm2 for the R/V Albatross. Estimates for 2009 are based on FSV Bigelow survey adjusted to an R/V Albatross equivalent by the calibration coefficient of 1.1468. A simple 3-yr moving average is used to estimate female SSB. The biological reference point for the stock size is 200,000 mt of female SSB. See text for additional details.

Year	Lengths >= 80 cm			Lengths 36 to 79 cm			Length <= 35 cm			All Lengths	3-pt average Fem SSB
	Females	Males	Total	Females	Males	Total	Females	Males	Total		
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Sources of Uncertainty in Stochastic F and Biomass Estimates

- Survey sampling design variability—variance of mean relative density estimate
- Measurement variability—Footprint of Survey
- Interannual variation in density—3 yr moving average
- Variability of discard estimates by gear type: trawls, gill net, and recreational
- Discard mortality
- Calibration variance—Bigelow to Albatross Equivalent

Stochastic F and Biomass Estimates

- The mean stochastic female SSB estimate for 2009 of 163,256 mt represents a slight decline from the 194,616 mt (based on the 2006-2008 data) but an increase from 141,350 mt in 2007 (2005-2007 data). Each estimate includes 3 years of data; the year identifies the last year in the 3-yr average.
- The incorporation of a larger average size trawl footprint reduces the target female SSB level to 167,800 mt from 200,000 mt. We emphasize that this change is due to the rescaling of the survey data associated with the increased footprint size.
- The uncertainty of the female spawning stock biomass estimate and its relationship to the target and threshold values is depicted in Fig. 8 (top). There is about a 99% probability that female SSB in 2009 exceeds the female threshold biomass level (83,900 mt). The probability that female SSB in 2009 exceeds the target biomass of 167,800 mt is about 43 %
- The median total biomass estimate for spiny dogfish is slightly more than 500,000 mt. Exploitable biomass is a function of the selectivity pattern in the fishery. Because the recent fishery harvests the largest fish in the population, the median exploitable biomass of female dogfish is 76,000 mt is lower than the female spawning stock biomass.
- Median exploitable biomass of male dogfish is about 270,000 mt.

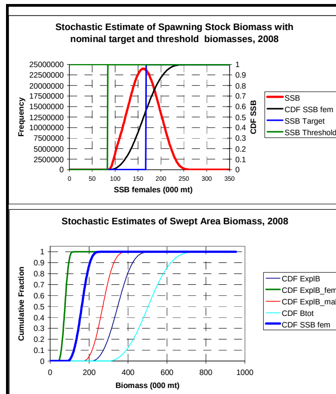


Fig 8. Estimates of female spawning stock biomass (top) and cumulative distribution functions for exploitable male and female biomass of spiny dogfish, for the 2007-2009 survey period.

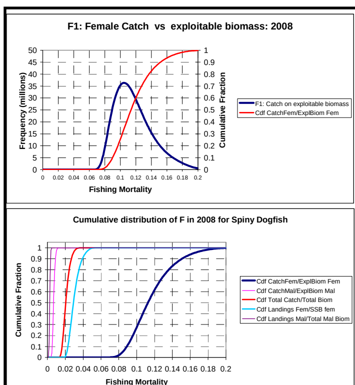


Fig. 9. Stochastic estimates of fishing mortality on spiny dogfish, 2008

Harvest Projections

- F_status quo=0.117
- F_rebuild=0.11
- F_target=0.284
- F_threshold = 0.39
- Uncertainty in future catches are induced by uncertainty in initial stock size magnitude and size composition
- No uncertainty in the biological reference points is considered. (Could be done via a parametric Monte Carlo, or in future model with integrated stock recruitment model).
- Can apply the P* method to compare distribution of catch under F rebuild with alternative sampling distributions

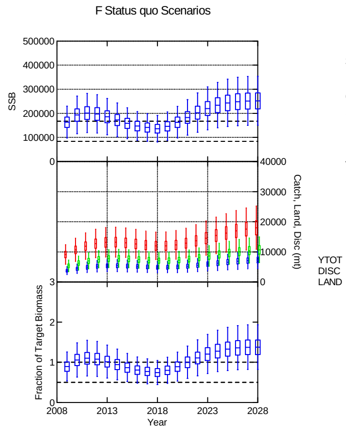


Fig 11. Predicted spawning stock biomass, catch, landings, discards, and ratio of SSB(t) to target biomass (167.8 k mt), 2009-2028 based on constant F harvest policy = F status quo. See Table 2

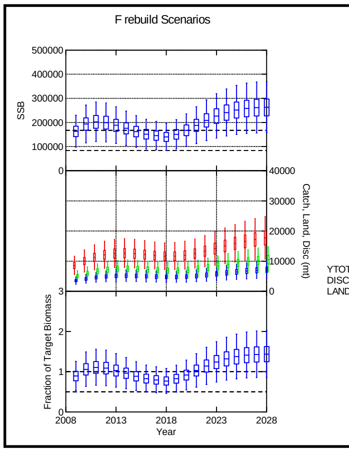


Fig 12. Predicted spawning stock biomass, catch, landings, discards, and ratio of SSB(t) to target biomass (167.8 k mt), 2009-2028 based on constant F harvest policy = F rebuild, See Table 3 .

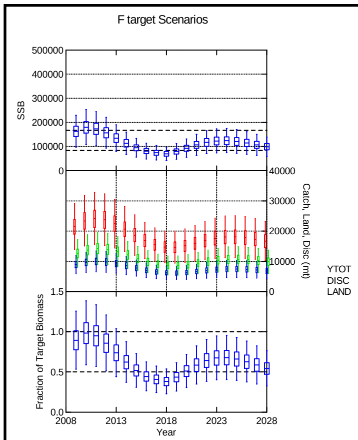


Fig 13. Predicted spawning stock biomass, catch, landings, discards, and ratio of SSB(t) to target biomass (167.8 k mt), 2009-2028 based on constant F harvest policy = Ftarget=0.284. See Table 4.

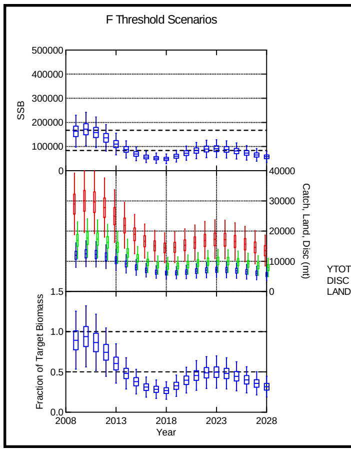
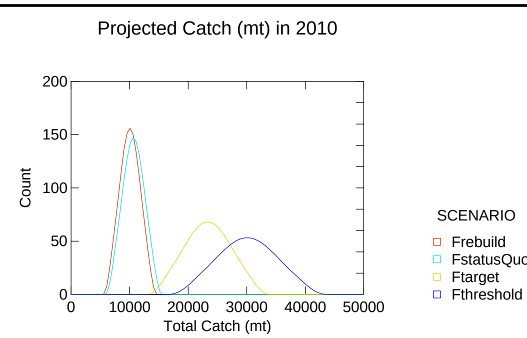
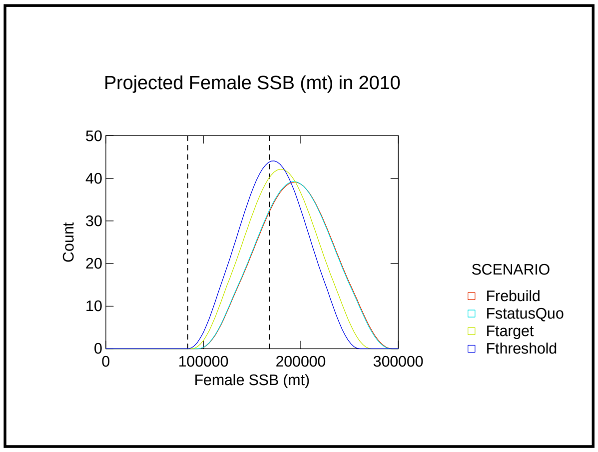


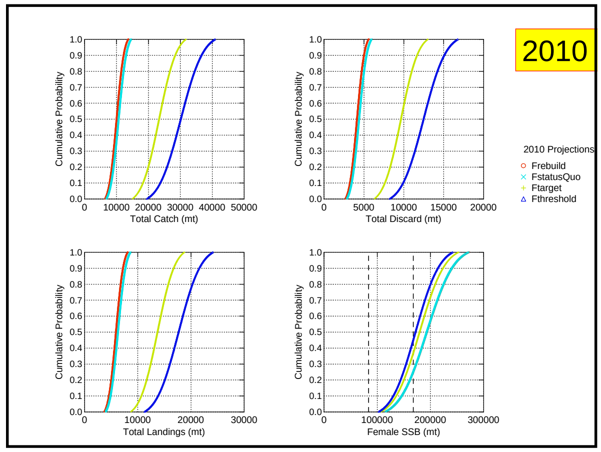
Fig 14. Predicted spawning stock biomass, catch, landings, discards, and ratio of SSB(t) to target biomass (167.8 k mt), 2009-2028 based on constant F harvest policy = Fthreshold=0.39, See Table 5.

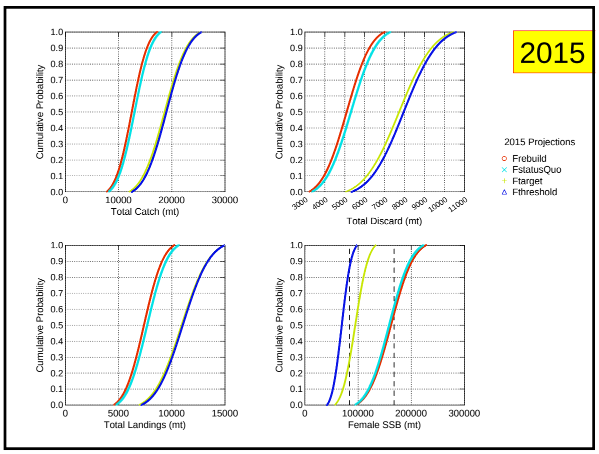
Scenario = FstatusQuo

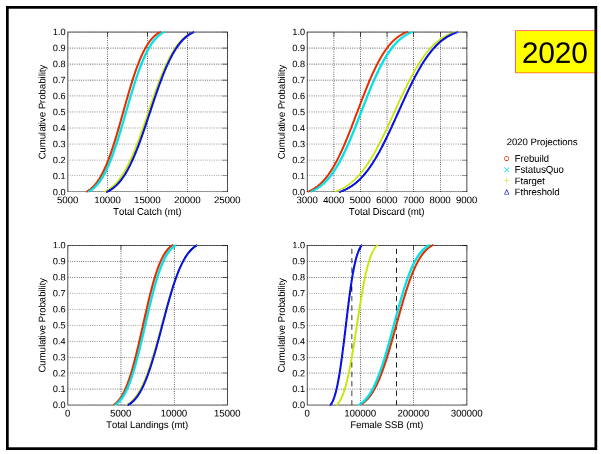
Year	F on females	F on males	SSB (mt)	Total Catch (mt)	Total Landing (mt)	Female Landings (mt)	Male Landings (mt)	Total Discards (mt)	Female Discards (mt)	Male Discards (mt)	SSB(t)/ SSB_target	Probabilty (SSB>SSB_target)	Probabilty (SSB> SSB_thresh)
	Average												
2009	0.117	0.003	163,304	9,127	5,347	4,794	553	3,780	3,188	592	0.893	0.27	1
2010	0.117	0.003	193,139	10,678	6,282	5,742	540	4,396	3,818	578	1.056	0.606	1.000
2011	0.117	0.003	201,208	11,911	7,026	6,501	525	4,885	4,323	562	1.100	0.678	1.000
2012	0.117	0.003	197,419	12,750	7,534	7,024	510	5,216	4,671	546	1.080	0.646	1.000
2013	0.117	0.003	185,783	13,156	7,780	7,282	498	5,375	4,842	533	1.016	0.532	1.000
2036	0.117	0.003	320,845	22,340	13,285	12,738	546	9,055	8,470	585	1.755	1.000	1.000
2037	0.117	0.003	335,525	23,250	13,828	13,269	559	9,422	8,823	599	1.835	1.000	1.000
2038	0.117	0.003	349,039	24,179	14,383	13,810	573	9,796	9,183	613	1.909	1.000	1.000
Average	0.117	0.003	225,029	15,933	9,450	8,956	494	6,484	5,955	528	1.231	0.671	0.998
Ave '09-18	0.117	0.003	169,651	12,075	7,129	6,624	505	4,945	4,405	541	0.928	0.351	0.995
Ave '19-28	0.117	0.003	214,303	14,968	8,879	8,421	458	6,089	5,599	490	0.000	0.000	0.000
Ave '29-38	0.117	0.003	291,132	20,757	12,341	11,823	518	8,416	7,862	554	0.000	0.000	0.000
Formula	*A*	*B*	*C*	*D=E+H*	*E=F+G*	*F*	*G*	*H=I+J*	*I*	*J*	*K*	*L*	*M*











Appendix 1. Approximate upper bound on efficiency of R/V Albatross for capturing spiny dogfish derived from comparison of capture rates with the FSV Bigelow

An inter-vessel calibration experiment attempts to relate the average catchability of vessel A to vessel B by comparing paired tow catch rates over a variety of habitats, bottom types and species densities. If we conveniently let subscript A refer to the Albatross and B refer to the Bigelow, then the expected index catch rate I can be expressed as

$$I_A = e_A a_A D$$
$$I_B = e_B a_B D$$

Where ***e*** represents efficiency, ***a*** is the average area swept and D is the true density.

The ratio of the index catches can be used to compute a calibration coefficient γ expressed as the ratio of I_B to I_A.

$$\frac{I_B}{I_A} = \gamma = \frac{e_B a_B D}{e_A a_A D} = \frac{e_B a_B}{e_A a_A}$$

$$\gamma = 1.1468 = \frac{e_B a_B}{e_A a_A} = \frac{e_B \, 637{,}899}{e_A \, 871{,}140}$$

$$\frac{e_A}{e_B} = 0.6385$$

If the Bigelow net were 100% efficient for spiny dogfish between the doors then the maximum possible Albatross efficiency would be 64%.

Calibration Coeffcient

1. The use of a calibration coefficient increases the variance of the estimated Albatross equivalent because this prediction includes the sampling errors of the original Bigelow survey value and the calibration coefficient. A Taylor series expansion method was used to estimate the variance as

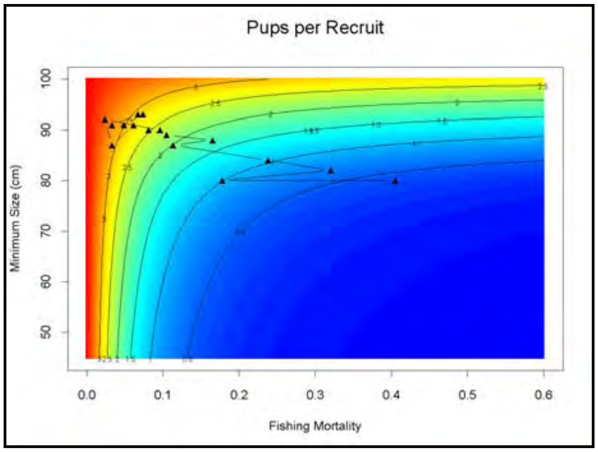
$$Var\left[\frac{I_{Bigelow}}{\gamma}\right] = \frac{Var\left[I_{Bigelow}\right]}{\gamma^2} + \frac{I^2_{Bigelow} Var[\gamma]}{\gamma^4}$$

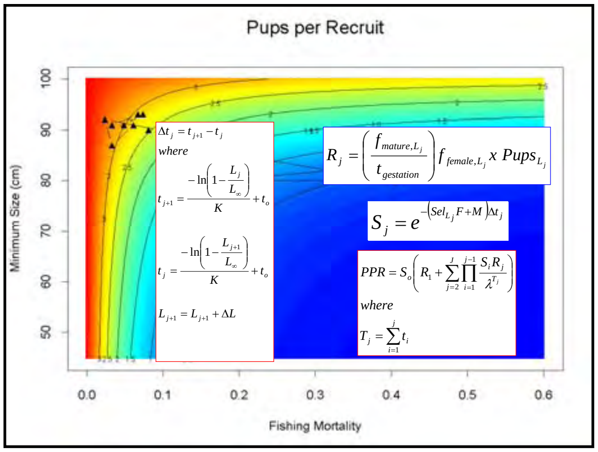
a. The average number of female dogfish per tow by the Bigelow was 30.3 with a standard error of 4.3. The predicted Albatross equivalent was 26.4 per tow with a standard error of 5.8.

Uncertainty in the Biological Reference Point for Biomass

Biological Reference Points

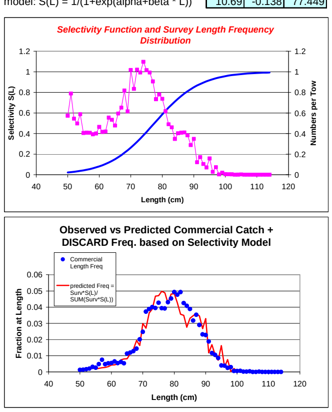
- Fishing mortality reference points based on life history model described in Rago et al 1998 with updates in 2006 SARC 43.
  - Major changes in selectivity over time alter the size-specific force of mortality for this resource.
  - These changes imply significant changes in the underlying F that would achieve an equilibrium population growth rate.





FEMALES, 3-yr Average, w/Discard 1998

	alpha	beta	L50%ile
model: S(L) = 1/(1+exp(alpha+beta * L))	10.69	-0.138	77.449

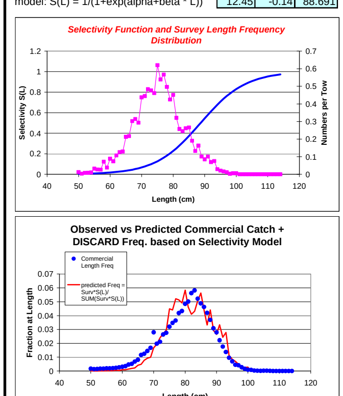


Changes in Selectivity: 1998

L50 = 77.4 cm

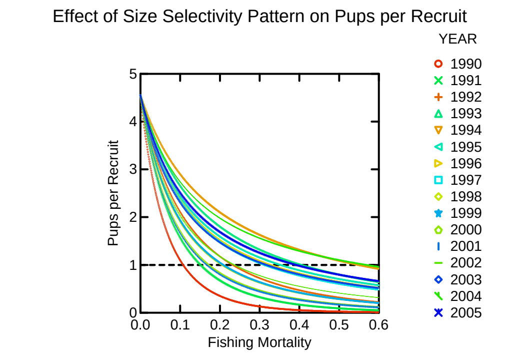
FEMALES, 3-yr Average, w/Discard 2005

	alpha	beta	L50%ile
model: S(L) = 1/(1+exp(alpha+beta * L))	12.45	-0.14	88.691



Changes in Selectivity: 2005

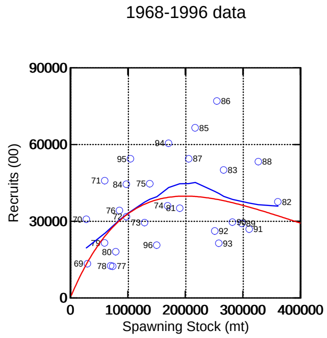
L50 = 88.7



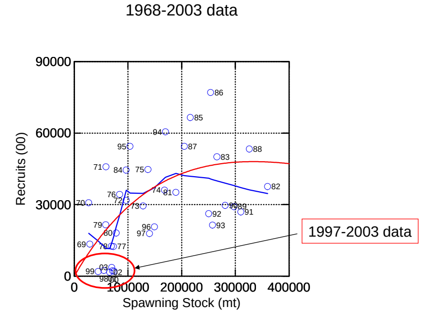
Effect of size selectivity of fishery and F on the expected pups per recruit. Abscissa represents F on fully-recruited length classes. Selectivity changes vary across years due to changes in commercial landings patterns and varying degrees of discard mortality.

Biological Reference Points for Female Spawing Stock Biomass

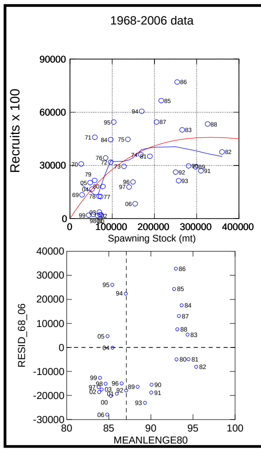
- Per the recommendation of the SSC in 1999, a Ricker stock recruitment relationship was used to develop the biomass reference point. This corresponds to the biomass for Rmax.
- Measures of steepness were not included nor is the Ricker function used in the forecasting model.
- The 200,000 mt reference point was approximate (actual value was 215, 000 mt)
- Changes in relationship between recruits and spawning stock appeared after 1997.



Parameter	Estimate	A.S.E.	Param/ASE	Lower < 95%>	Upper
A	0.541578	0.109155	4.961551	0.317610	0.765546
B	-0.000005	0.000001	-4.914719	-0.000007	-0.000003
RMAX	4.28385E+04	3517.026798	12.180306	3.56221E+04	5.00548E+04
SSBMAX	2.15014E+05	4.37491E+04	4.914719	1.25249E+05	3.04780E+05



Parameter	Estimate	A.S.E.	Param/ASE	Lower < 95%>	Upper
A	0.391858	0.085433	4.586732	0.218043	0.565672
B	-0.000003	0.000001	-3.464742	-0.000005	-0.000001
RMAX	4.23876E+04	5295.638721	8.004238	3.16135E+04	5.31616E+04
SSBMAX	2.94040E+05	8.48665E+04	3.464730	1.21377E+05	4.66702E+05



- Comparison of parametric and non-parametric stock-recruitment model fits for spiny dogfish captured in NMFS spring survey for 1968-2006 (top).
- Nonparametric model fit is based on lowess smooth with tension=0.6.
- For 1968-1996, estimated SSBmax, of 215 k mt, corresponded to average catch of 33.2 kg mature females/tow.
- Estimated SSBmax for the 1968-2006 period increases to 304 k mt or 46.8 k mt.
- Model residuals from Ricker model vs mean length of mature female spiny dogfish(bottom)
- Odds ratio test statistic suggests that odds of recruitment less than model prediction is 4.5 times greater when females are below median size of 87 cm.

Discussions at TRAC on next Dogfish Assessment Model

- Need model with sufficient realism yet supportable by the data
- General movement patterns evident but quantification of flux is difficult
- Major information gaps in landing and surveys
- Major transition in US surveys
- Discard information sparse
- Minimize imputation

General Model Structure for TRAC

- Two Spatial units
  - US
  - Canada
- Two time periods within year
  - May(t)-October(t)
  - Nov(t)-Apr(t+1)
- Assessment Period
  - 1986-2008
  - Use of earlier period depends on assumptions about discard rates, size and sex composition
- Fisheries (Landings and Discards)
  - Gill net
  - Trawl
  - Longline/Hook
- Two Sex Model
- Mechanistic Stock Recruitment Relationship incorporating size-dependent effects

End

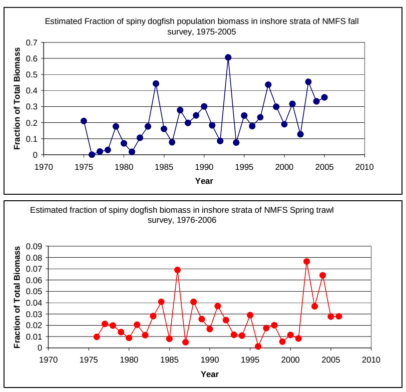


Fig. 10. Fraction of total spiny dogfish swept-area estimates of population biomass in inshore strata in NMFS fall (top panel) and spring (bottom) bottom trawl survey.

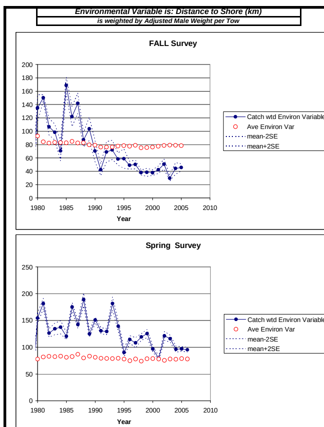


Fig. 11. Comparison of average distance from shore (km) for samples taken in NMFS fall (open dots) and spring surveys with distances weighted by male spiny dogfish adjusted weight per tow (kg) (closed dots). Adjustments account for effect of gear and vessel changes. Distance to shore represent closest distance from sample station to shore.

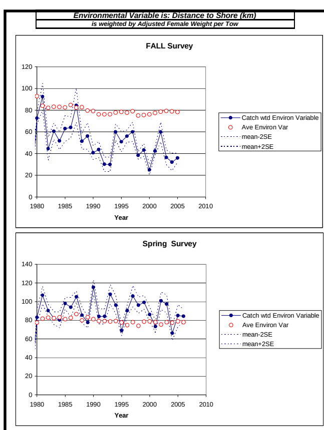


Fig. 11. Comparison of average distance from shore (km) for samples taken in NMFS fall (open dots) and spring surveys with distances weighted by female spiny dogfish adjusted weight per tow (kg) (closed dots). Adjustments account for effect of gear and vessel changes. Distance to shore represent closest distance from sample station to shore.

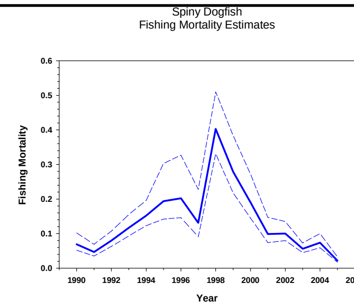


Fig. 18. Estimated fishing mortality rates on mature female dogfish, 1990-2005. Dashed lines represent 80% confidence intervals

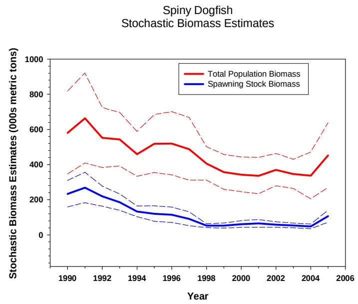
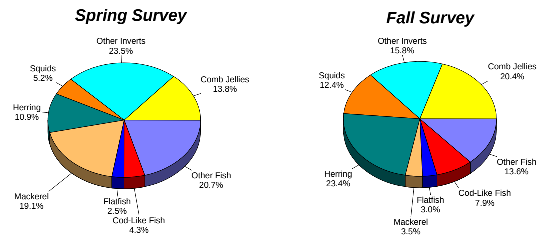


Fig. 17. Average total biomass and female spawning stock biomass (000 mt) based on stochastic estimation model. Dashed lines represent 80% confidence intervals.

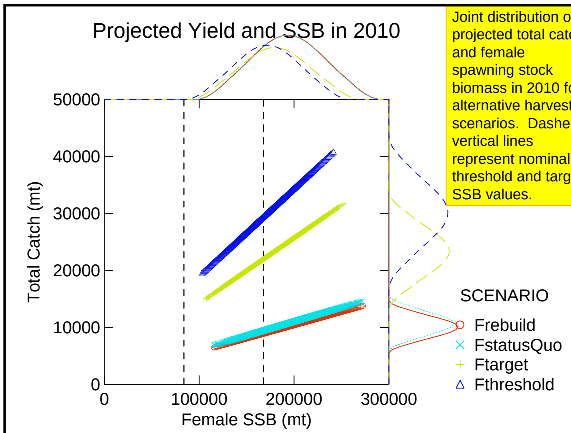
Dogfish Food Habits: **A starting point for ecosystem implications. Dogfish are omnivorous feeders who diets vary seasonally. Pelagic fish constitute a large fraction of the diet, but groundfish, particularly cod, do not.**



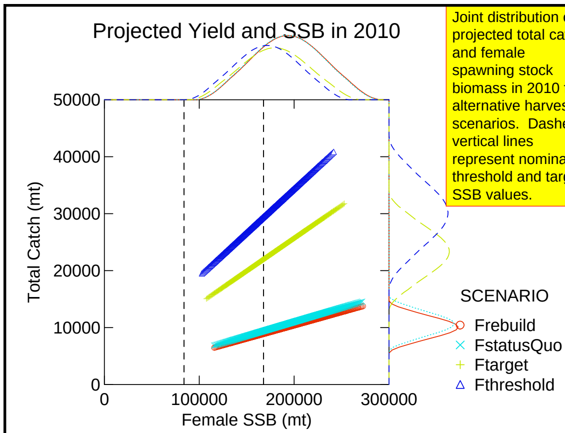
Based on 40,000 stomachs examined (Fall and Spring)

Courtesy of Jason Link, NMFS

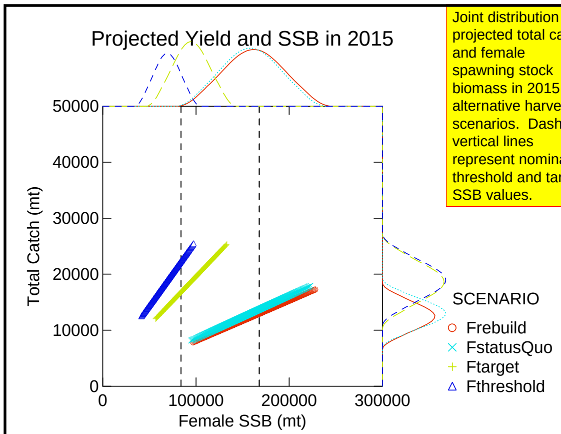
Joint distribution of projected total catch and female spawning stock biomass in 2010 for alternative harvest scenarios. Dashed vertical lines represent nominal threshold and target SSB values.



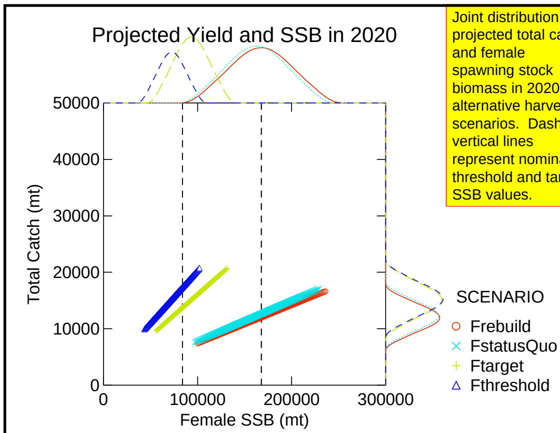
Joint distribution of projected total catch and female spawning stock biomass in 2010 for alternative harvest scenarios. Dashed vertical lines represent nominal threshold and target SSB values.



Joint distribution of projected total catch and female spawning stock biomass in 2015 for alternative harvest scenarios. Dashed vertical lines represent nominal threshold and target SSB values.



Joint distribution of projected total catch and female spawning stock biomass in 2020 for alternative harvest scenarios. Dashed vertical lines represent nominal threshold and target SSB values.



<u>Briefing Item D</u>: Staff Recommendations

MID-ATLANTIC FISHERY MANAGEMENT COUNCIL

Richard B. Robins, Jr.
Chairman

Lee G. Anderson
Vice-Chairman

ROOM 2115 FEDERAL BUILDING
300 South New Street
Dover, Delaware 19904-6790
Tel 302-674-2331
Toll Free 877-446-2362
Fax 302-674-5399
www.mafmc.org

Daniel T. Furlong
Executive Director

M E M O R A N D U M

TO: **Science and Statistical Committee, Spiny Dogfish Monitoring Committee**

FROM: **Jim Armstrong, Spiny Dogfish Monitoring Committee Chairman**

DATE: **October 19, 2009**

SUBJECT: **Staff Recommendation on Spiny Dogfish ABC, Commercial Quota and Trip Limits for the 2010 Fishing Year**

Please find in a separate attachment a pre-dissemination status update from Paul Rago and Kathy Sosebee. The staff recommendation contained herein is based on that status update as well as associated consultation by staff with the Paul and Kathy and SSC Chairman, John Boreman.

Current Stock and Management Conditions

<u>Stock Biomass</u>
The updated stochastic estimate of mature female biomass (SSB) for 2009 is about 2.7% below SSB_{max}, the proxy for B_{msy} target based on data from 1968 to 1996. Specific estimates of SSB are 163,256 mt under the Commission's plan (SSB_{max} = 167,800 mt) and about 194,584 mt under the Federal plan (SSB_{max} = 200,000 mt). The different SSB and SSB_{max} values reflect different assumptions in the plans about the average size of the survey trawl "footprint" used to estimate total swept area biomass. This is a scaling factor, however, meaning that the values are functionally equivalent. Technically speaking, no official biomass target exists in the Federal FMP since the SSC-recommended biomass target of SSB_{max} was reduced to 90% SSB_{max} by the Councils when the FMP was submitted. This reduction in the biomass target led to partial approval of the FMP by the NMFS. This technicality is expected to be resolved through Framework Adjustment 2 to the FMP, which will permit automatic incorporation of biological reference points into the FMP as they are recommended through peer-reviewed benchmark assessments (such an assessment is expected to occur in early 2010). The probability that the SSB_{2008} is above SSB_{max} is estimated to be 42%. The probability that SSB_{2008} is above the biomass threshold (1/2 SSB_{max}) is approximately 100%. Thus, *the stock is not overfished*.

Fishing Mortality

Several sources of removals contribute to the estimate of F for 2008. These include U.S. commercial landings (4,108.2 mt), Canadian commercial landings (1,572.3 mt), U.S. discards (4,933.6 mt), and U.S. recreational landings (213.6 mt). Total removals in 2008 were approximately *10,828 mt* corresponding to a stochastic F estimate of F_{2008} = 0.11742, well below the overfishing threshold of F = 0.39 and essentially equivalent to $F_{rebuild}$ = 0.11. The probability that *overfishing is not occurring* ($F_{2008} < F_{threshold}$) is approximately 100%.

Projections

Four projection scenarios of stock biomass, landings, and fishing mortality rate are presented in the status update. These include: $F_{status\ quo}$, $F_{rebuild}$, F_{target} (for a rebuilt stock), and $F_{threshold}$. The projection time frame for each scenario was 2008-2038 (See Tables 2 – 5 in the report). All of these long-term projections are characterized by oscillations (See Figures 11 – 14). A decline in projected SSB after 2011 is expected due to the recruitment into the SSB of the small 1997-2003 year classes. After projected SSB reaches a low level in about 2017, a subsequent increase is expected, however this increase is dependent on the assumption that pup survival rates will increase. A remarkable increase in survey catch of pups occurred this year. This is also the first year in which the spring trawl survey was conducted using the FSV Bigelow instead of the R/V Albatross. A calibration coefficient was used to convert the Bigelow catch into predicted Albatross equivalents. The conversion factor for number-per-tow and weight-per-tow were quite similar suggesting that the spike in the catch of pups was not due to differences in size selectivity. See Section B and Figure 2A in the status update for more detail.

Last year, the SSB estimate was above the biomass target, however, staff and the Monitoring Committee were reluctant to officially declare the stock to be rebuilt. This year, since the SSB estimate has moved to slightly below the biomass target we are obligated to make recommendations appropriate to a stock that is undergoing rebuilding. Accordingly, ABC should be reduced from OFL (catch associated with $F_{threshold}$; 0.39) to a level that will contribute to stock rebuilding. As such, the staff recommendation to the SSC is to set ABC based on the projections associated with $F_{rebuild}$ (0.11; see Table 3 in the status update). The projected catch associated with $F_{rebuild}$ is 10,064 mt (22.187 M lb). A direct estimate of $p(F<F_{threshold})$ for a catch at ABC is not estimable in the projection model. It is possible to calculate where in the distribution of projected catches at $F=F_{threshold}$, ABC occurs. That calculation is forthcoming, but is likely to result in a rather small value given the probability that $p(F_{2008} < F_{threshold})$ was ~ 100%. Other sources of uncertainty are listed under item 7 on page 10 of the status update.

For the Monitoring Committee, staff essentially reminds the Committee that given the stock status, we are obligated under the FMP to set management measures to achieve $F_{rebuild}$. Therefore, based on the F-rebuild projection (Table 3) staff recommends a commercial quota for 2010 of 5,921 mt (13.054 M lb). Staff also recommends that the commercial quota be set for one fishing year since a benchmark Transboundary Resource Assessment Committee (TRAC) assessment is expected to take place in early 2010. Status quo (3,000 lb) trip limits are also recommended.

A summary of the staff recommendations are provided in the tables below.

Staff Recommendations to SSC for 2010 Spiny Dogfish Fishery

	Basis	Catch mt	Catch M lbs	Landings mt	Landings M lbs	p(SSB > SSBtarg)	SSB2010 / SSB2009
OFL	**$F_{threshold}$ = 0.39**	30,121	66.405	17,659	38.931	0.370	1.052
ABC	**$F_{rebuild}$ = 0.11**	10,064	22.187	5,921	13.054	0.612	1.186

Spiny Dogfish Summary for 2008 for Comparison with Values in above Table

F_{targ}	F_{2008}	Catch mt	Catch M lbs	Landings mt	Landings M lbs
Frebuild (0.11)	**0.11742**	10,828	23.872	5,894	12.994

Staff Recommendations to MC for 2010 Spiny Dogfish Fishery

	Basis	Catch mt	Catch M lbs	Landings mt	Landings M lbs	Periodic Allocation of Quota (M lbs) Period 1	Periodic Allocation of Quota (M lbs) Period 2	Trip Limits (lbs) Period 1	Trip Limits (lbs) Period 2
ACL	**$F_{rebuild}$ = 0.11**	10,064	22.187	5,921	13.054	7.558	5.496	3,000	3,000

cc: Robins, Anderson, Munden, Furlong, Kellogg, Vonderweidt