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Abundance and Distribution of Elasmobranchs from the NMFS Northeast Fisheries Science Center Research Vessel Bottom Trawl Surveys

by

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ABSTRACT

Research vessel bottom trawl survey data were examined for occurrence of elasmobranchs. Thirty species were found including large and small sharks and stingrays. Of the 12 species examined for distributional patterns, 11 elasmobranchs exhibited large seasonal shifts in distribution from south to north or offshore to inshore as water temperatures warmed. The exception to this was chain dogfish which generally remained in deep slope waters year round.

Indices of relative abundance for spiny dogfish showed and increase from the late 1970s to the early 1990s. Biomass indices show a slight decline over the last five years. This change is due largely to the decline in adult female biomass (> 80cm). Fishing mortality on large female spiny dogfish has increased from low values (~0.05) in the 1980s to values ranging from 0.35-0.5 during 1997-1999.

INTRODUCTION

The Northeast Fisheries Science Center (NEFSC) has conducted research vessel bottom trawl surveys in the autumn since 1963, in the spring since 1968 (Azarovitz, 1981) and, in 1992, instituted a winter survey using more efficient sampling gear. These surveys, originally designed for major groundfish such as cod, haddock, and yellowtail flounder, are also useful for a variety of other species, including elasmobranchs. The surveys have generally covered the waters from the Scotian Shelf in Canada to Cape Hatteras, North Carolina. Fisheries have developed for some of the elasmobranch species sampled in the survey (i.e spiny dogfish). This paper examines the occurrence, distribution and abundance of selected species of elasmobranchs from the NEFSC bottom trawl surveys.

METHODS

The NEFSC winter, spring, and autumn surveys were examined for the occurrence of elasmobranchs (except skates). For those species in which 100 or more individuals were caught over the entire time series, seasonal and spatial changes in distribution were examined.

Abundance, biomass, and fishing mortality were estimated for spiny dogfish only. A relative survey index was estimated for spring and autumn using the method of Cochran (1977). The Beverton-Holt (BH) estimator provides an average fishing mortality that is conditional on the size at entry to the fishery (L_{CRIT}) and natural mortality rate (M) (Beverton and Holt, 1956).

The Beverton and Holt (1956) estimator is:

$$Z = (K(L_{inf} - L_{bar})) / (L_{bar} - L_{crit}).$$

We used the 25th percentile of size of females in the commercial fishery as an estimate of the Lcrit in the BH model. The reduction in biological sampling in the dogfish fishery (2 samples in 1998, 5 in 1999) precludes reliable estimation of this parameter for the last two years. Since 1989 the 25th percentile of length in the fishery has been trended downward as fewer large females remained in the population, as the market accepted smaller sized fish, and as males began to comprise an increasing proportion of the landings (NEFSC 1998).

The natural mortality rate for dogfish is uncertain. We assumed a maximum age of 50 years, which in turn, implies a natural mortality rate of about 0.09 (supported by a variety of methods, NEFSC 1994). Maximum ages exceeding 100 years have been validated in Pacific populations off British Columbia. In Europe tags have been recovered from male dogfish at large for almost 35 years. During this time the tagged fish grew from 66 to 78 cm **C** less than 0.34 cm per year.

To address the uncertainties with respect to size at entry to the fishery and natural mortality, we updated the mortality estimates through 1999 and conducted a sensitivity analysis of the BH estimator. Size at entry to the fishery was varied between 70 to 90 cm in 5 cm increments. We also evaluated two alternative values of natural mortality. If the maximum age is set at 75 years, then the mortality rate that would allow 1% of the new recruits to survive to age 75 is 0.0614 per year. Since the BH model estimates Z rather than F, the net effect of increasing longevity is to increase estimates of F by the difference of the derived natural mortality rates by a constant = 0.031. [i.e., F= Z-M. $M_{50\text{-}YR}$ =0.092, $M_{75\text{-}YR}$ = 0.061. Therefore the maximum difference in F associated with variations in M is $M_{50\text{-}YR} - M_{75\text{-}YR}$ = 0.031.]

RESULTS AND DISCUSSION

Thirty (30) species of elasmobranchs were sampled in the NEFSC surveys (Tables 1-3), with the autumn survey capturing the greatest number of species. Some species were only taken once over the 37 years of the surveys (i.e. blacknose shark, blacktip shark, shortfin mako), while others have been very abundant with several thousand to one million individuals caught during the survey series (smooth and spiny dogfish).

The distribution of most species of elasmobranchs sampled in the surveys varied seasonally. The Atlantic angel shark is found in southern slope waters only in winter (Figure 1). As water temperatures increased, this species migrates to inshore areas (Figure 2). In autumn, the distribution is largely inshore and slightly northward (Figure 2). This same type of migration is seen in smooth dogfish. In winter, both males and females are found primarily in slope waters south of Delaware Bay (Figures 3 and 4). In spring, smooth dogfish have begun to move inshore at the southern end of the survey area as water temperatures increase. (Figures 5 and 6). By the autumn survey, individuals are found as far north as Cape Cod (Figures 5 and 6). Many other species migrate northward in autumn from southern inshore areas. The Atlantic sharpnose shark (Figure 7) and all of the stingrays (Figures 8-12) move north but stay well inshore. The larger sharks also move northward, but are much more widespread and occur in deeper waters than the stingrays (Figures 13 and 14). Spiny dogfish show the greatest degree of movement migrating from offshore southern waters (south of Georges Bank) to the Gulf of Maine and into Canadian waters (Figures 15-18). Spiny dogfish may move as far north as Newfoundland in the summer and fall (NEFSC, 1994). The only species to show little seasonal movement is the chain dogfish which generally resides in the slope waters of the Mid-Atlantic year round (Figures 19 and 20).

Both spring and autumn survey indices of abundance and biomass for spiny dogfish show considerable variability (Tables 4 and 5; Figure 21). Both sets of indices indicate an overall increase in abundance and biomass since the early 1970s, although the autumn survey indices have generally increased less than those in the spring survey. In recent years, spiny dogfish biomass has declined due to a reduction in adult female biomass (Table 6, Figures 22 and 23). In the late 1980s, the area-swept biomass of females greater than 80cm (mature biomass) averaged around 200 thousand mt (and there were large numbers of fish greater than 90 cm in the stock). Since 1997, mature female biomass estimate has declined to a three-year average of around 50,000 mt and the size structure has become truncated. There are still considerable amounts of males and immature females, however.

Fishing mortality on spiny dogfish was low throughout most of the 1980s (Figure 24). Fishing mortality increased in the 1990s and in 1999 was about 90 times higher than those in the mid-1980s.

The results of the sensitivity analyses to size at capture and natural mortality are shown in Figure 24 and are summarized in Tables 7 and 8. The point estimates for each value of L_{crit} differ slightly from one other, but the overall trend in fishing mortality is the same. The magnitude of change in fishing mortality between the mid-1980s and 1999 depends on the value of L_{crit}. The difference in all cases is still at least five-fold.

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Table 1. Numbers of elasmobranch individuals caught in the NEFSC autumn survey from 1963-1999.

Year	Atlantic Angel Shark	Atlantic Sharpnose Shark	Atlantic Stingray	Atlantic Torpedo Ray	Basking Shark	Black Dogfish	Blacknose Shark	Blacktip Shark	Bluntnose Ray	Broadband Dogfish	Bullnose Ray	Chain Dogfish	Cownose Ray	Dusky Shark	Lesser Electric Ray	Manta Ray	Night Shark
1963				1								5					
1964				2								10					
1965				1								4					
1966												3					
1967	2			1					4		14	4		1			
1968	1					1					4	2		5			
1969	9			1					4			3		6			
1970	4											3					
1971	5											4					
1972	10					1						5	20	4			
1973	9			2		2			2		7	3					
1974	11	1		2		1			6		3	1					
1975	32			1					43		50	3		1			
1976	13		2	3					62		73		19	21			
1977	36		2	1					113		21	1	33	21			
1978	13								28		13		3	2			
1979	7	45		1					36		41	5	12	1			
1980	22	7		1					48		87	3	3				
1981	15	64		4		3			107		144	6	5		1	2	
1982	10	48							26		56	2	13				
1983	6	81		1			1		31		123	2	2	1			
1984	13	5							109		54		33				
1985	9								43		59	7	38	10			
1986	13					8			27		69	2	9	22			
1987	8	45	1			1			6		24	2					
1988	7	8		2		1		1	5		15	4					
1989	7	14		1	1				102		145	4	16				
1990	5	15	2						27		127	12	34				
1991	10	11	3	2	1				17	44	84	2	2	2			
1992	9	15							18		29	4	1	1			
1993	7	24	1	1					14		58	21	2	1			
1994	4	2		1					70		27	9					
1995	2	38							75		128	6	23	1	2		
1996	6	15		3		2			80		48	7	10				
1997	5	73		3					30		53	12	3	2			2
1998	12	14		4					34		95	29	60				
1999	1	9		1					52		132	14	13	1			
Total	323	534	11	40	2	20	1	1	1219	44	1783	204	354	103	3	2	2

continued.

Roughtail Stingray	Sand Tiger Shark	Sandbar Shark	Scalloped Hammerhead Shark	Shortfin Mako	Smooth Butterfly Ray	Smooth Dogfish	Southern Eagle Ray	Southern Stingray	Spiny Butterfly Ray	Spiny Dogfish	Spotted Eagle Ray	Thresher Shark
										3706		
						8				3106		
										2552		
										2335		
1	9	4				89		6		7862		
						74		20		4594		
2						31		21		6212		
										3880		
	3					31				2833		
18						60				2552	3	
2		3	1			118		7	1	3425		
1		1				58				1106		
22	11	20			1	663		3	19	6872		
14	4	2			6	1117		1	22	5216		
7	2	4			4	1144	1	1	14	2398		
6	6				3	958			17	15786	5	
5	2	6				322		1	10	16458		
7	8	2	2	1		484		2	26	2351		
6		2	1			606		1	47	23117		
29	1	10	3			443		11	13	7085		
32		4	1			183		1	13	22599		
8	2	8				545			22	21754		
33	1	2				460			17	16687		
11	2	2				723		5	14	12425		
8		4				242			1	11215		1
7		7				302			5	10433		
37		1			2	642		4	13	5797		
10		12				536			8	17828		
13	1	2				382		1	15	17639		1
11		1				209			13	12421		
9			1		1	298			6	6687		1
5	2	20				259			8	8288		
14	1	4	1		6	331			17	13370		
3		2			2	401			19	11077		
7	15	6				275		2	9	13552		
18		5			2	817		3	38	16663		1
4	2	4			18	569			28	10787		
350	72	138	10	1	45	13380	1	90	415	352668	8	4

Table 2. Numbers of elasmobranch individuals caught in the NEFSC spring survey from 1968-1999.

Year	Atlantic Angel Shark	Atlantic Sharpnose Shark	Atlantic Stingray	Atlantic Torpedo Ray	Black Dogfish	Bluntnose Ray	Broadband Dogfish	Bullnose Ray	Chain Dogfish	Cownose Ray	Dusky Shark	Lesser Electric Ray	Roughtail Stingray	Sand Tiger Shark
1968	10			1					7					
1969	11								3					
1970	12			2					7					
1971	22			2					15					
1972	6			1	4				9		3			
1973	10			3					29					
1974					28				3					3
1975				3					1					
1976	13			4				1	10				2	1
1977	55			3				4	28		5			2
1978	7			1					19					
1979	12			2					2					
1980	27			5					38					
1981	2			1	5				41					
1982	30	2		7	4	18		6	28				7	4
1983	5		2	1	1	15		5	7	5	1		6	1
1984	7	6				14		15	5		2		2	1
1985	10	3			10	10		3	3	1			8	1
1986	22			3	1	2		7	15		2		1	
1987	7				1			3	10	1	4			
1988	7					7		1	3		4		5	
1989	10			1				2	7		2		1	1
1990	19			1	6			8	5				9	
1991	7	1				2			10				2	
1992	3				1	1			3					
1993	5			1	1	1		3	1					1
1994	2							1	10		1		1	1
1995	4	1				1			1				3	
1996	1			1					2					
1997	8			1		9		3	27	5	1	2		
1998	23						5	1	14				2	
1999	16	7						1	18					
Total	373	20	2	44	62	80	5	64	381	12	25	2	49	16

continued.

Sandbar Shark	Scalloped Hammerhead Shark	Smooth Butterfly Ray	Smooth Dogfish	Southern Stingray	Spiny Butterfly Ray	Spiny Dogfish
			33			10053
			1			5266
			2			6514
			1			5771
			238			10326
			19			24109
			461			9770
			47			9449
7			86			9426
			143			6076
			66			11244
			18			6478
			22			18749
			1			29732
6			941		22	21857
17			407		14	16096
7		1	176		14	7128
9			445		8	27607
			248		7	12162
			139		3	23581
5			58		6	18023
1	1		827	2	8	20588
9		5	64		1	29840
1			87		8	18641
4			102	6		19881
5			337		2	14784
	1		64	1	1	32549
6			189			11427
			410			24246
18			259	5	13	13745
2			450		1	11072
			70		15	11953
97	2	6	6411	14	123	498143

Table 3. Numbers of elasmobranch individuals caught in the NEFSC winter survey from 1992-1999.

Year	Atlantic Angel Shark	Atlantic Torpedo Ray	Black Dogfish	Bluntnose Ray	Chain Dogfish	Smooth Dogfish	Spiny Dogfish
1992	2				40	483	23829
1993	4	1			6	22	38810
1994	5	1		1	1	903	49479
1995	22				18	758	35950
1996	61				67	574	22596
1997	9	1			28	1912	18916
1998	17	1	1	1	37	453	20266
1999	6				68	614	36731
Total	126	4	1	2	265	5719	246577

Table 4. Stratified mean number per tow indices for spiny dogfish from NEFSC spring (1968-1999) and autumn (1967-1999) bottom trawl surveys (offshore strata 1-30, 33-40, 61-76; Footnotes A-C).

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

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

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

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

Table 5. Stratified mean weight per tow (kg) indices for spiny dogfish from NEFSC spring (1968-1999) and autumn (1967-1999) bottom trawl surveys (offshore strata 1-30, 33-40, 61-76; Footnotes A-C).

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

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

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

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

Table 6. Biomass estimates for spiny dogfish (thousands of metric tons) based on area swept by NEFSC trawl during spring surveys, 1968-1999.

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

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

Table 7. Sensitivity analysis of trends in estimated total mortality rat
dogfish for alternative sizes at entry into fishery, 1980-19
Von Bertalanffy parameters: Lmax = 105, K= 0.092

	Size (cm)\ at Entry to Fishery				
year	70	75	80	85	90
1980	0.071	0.082	0.103	0.148	0.239
1981	0.055	0.065	0.082	0.114	0.185
1982	0.063	0.067	0.070	0.091	0.137
1983	0.106	0.089	0.084	0.087	0.128
1984	0.109	0.098	0.094	0.102	0.147
1985	0.118	0.115	0.108	0.102	0.114
1986	0.099	0.101	0.105	0.120	0.143
1987	0.091	0.100	0.099	0.126	0.110
1988	0.095	0.099	0.102	0.107	0.119
1989	0.193	0.207	0.221	0.195	0.188
1990	0.152	0.147	0.167	0.172	0.219
1991	0.161	0.169	0.168	0.181	0.199
1992	0.224	0.253	0.286	0.264	0.201
1993	0.167	0.174	0.190	0.203	0.223
1994	0.242	0.268	0.288	0.327	0.325
1995	0.366	0.409	0.406	0.403	0.429
1996	0.270	0.301	0.319	0.414	0.527
1997	0.467	0.579	0.631	0.634	0.646
1998	0.427	0.460	0.496	0.538	0.520
1999	0.434	0.523	0.599	0.671	0.529

Table 8. Sensitivity analysis of trends in estimated fishing mortality r
dogfish for alternative sizes at entry into fishery, 1980-19
assumed to be 0.092. Slightly negative values of F are
Von Bertalanffy parameters: Lmax = 105, K= 0.092

	Size (cm)\ at Entry to Fishery				
year	70	75	80	85	90
1980	0.000	0.000	0.011	0.056	0.147
1981	0.000	0.000	0.000	0.022	0.093
1982	0.000	0.000	0.000	0.000	0.045
1983	0.014	0.000	0.000	0.000	0.036
1984	0.017	0.006	0.002	0.010	0.055
1985	0.026	0.023	0.016	0.010	0.022
1986	0.007	0.009	0.013	0.028	0.051
1987	0.000	0.008	0.007	0.034	0.018
1988	0.003	0.007	0.010	0.015	0.027
1989	0.101	0.115	0.129	0.103	0.096
1990	0.060	0.055	0.075	0.080	0.127
1991	0.069	0.077	0.076	0.089	0.107
1992	0.132	0.161	0.194	0.172	0.109
1993	0.075	0.082	0.098	0.111	0.131
1994	0.150	0.176	0.196	0.235	0.233
1995	0.274	0.317	0.314	0.311	0.337
1996	0.178	0.209	0.227	0.322	0.435
1997	0.375	0.487	0.539	0.542	0.554
1998	0.335	0.368	0.404	0.446	0.428
1999	0.342	0.431	0.507	0.579	0.437

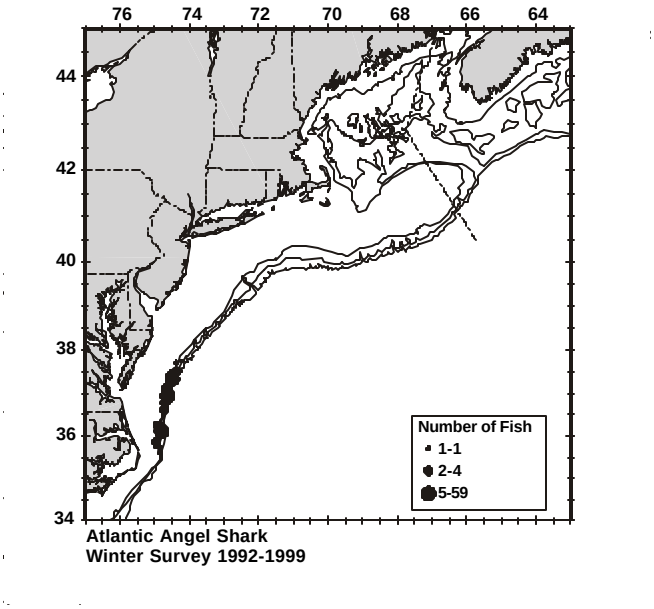

Figure 1. Distribution of Atlantic angel shark in NEFSC winter surveys from 1992-1999.

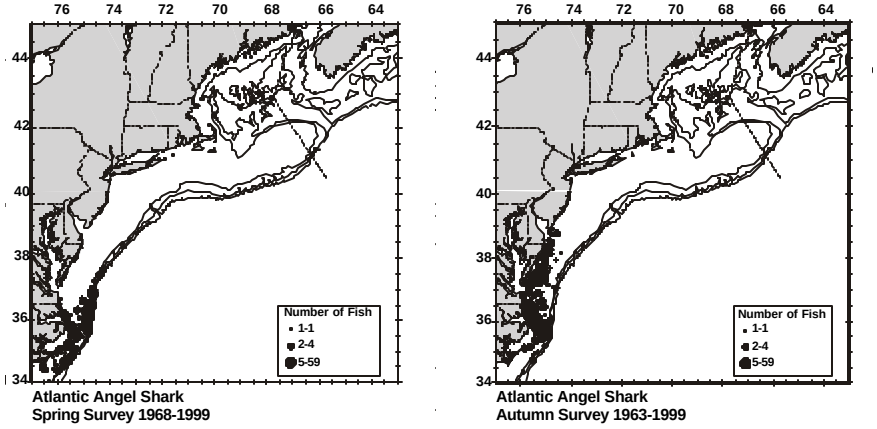

Figure 2. Distribution of Atlantic angel shark in the NEFSC spring and autumn surveys from 1963-1999.

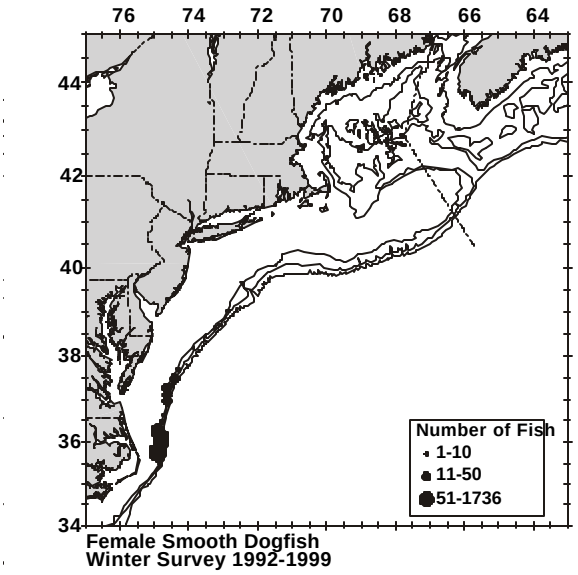

Figure 3. Distribution of female smooth dogfish in NEFSC winter surveys, 1992-1999.

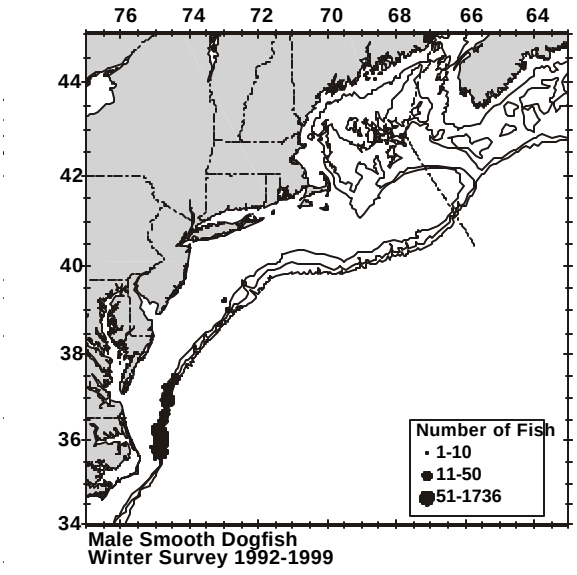

Figure 4. Distribution of male smooth dogfish in NEFSC winter surveys, 1992-1999.

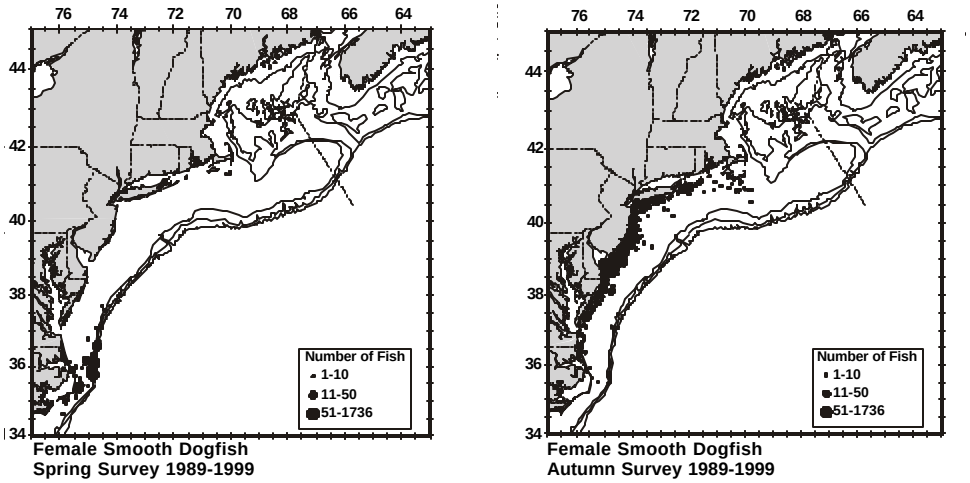

Figure 5. Distribution of female smooth dogfish in the NEFSC spring and autumn surveys from 1989-1999.

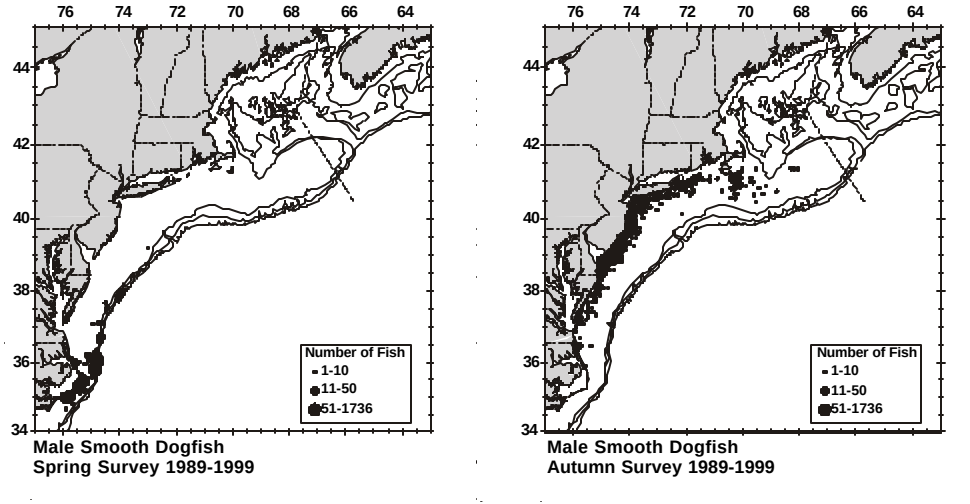

Figure 6. Distribution of male smooth dogfish in the NEFSC spring and autumn surveys from 1989-1999.

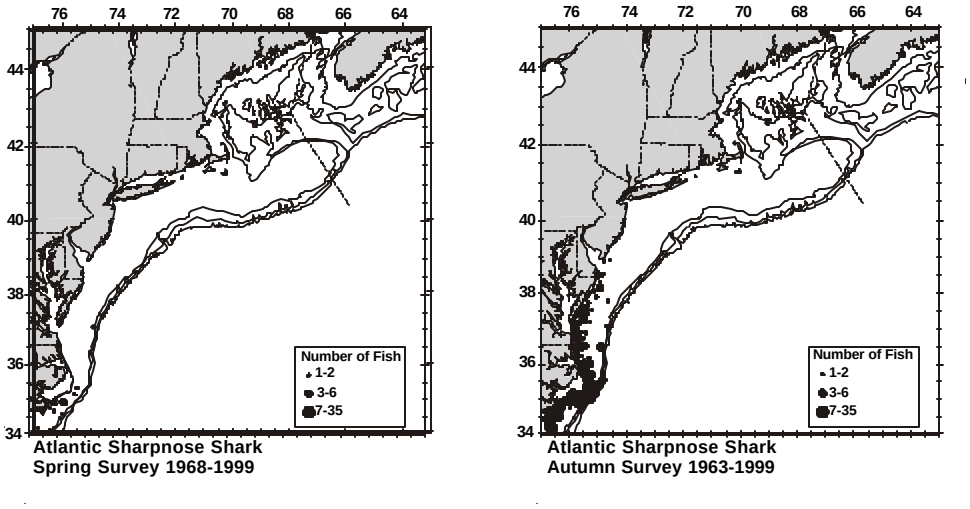

Figure 7. Distribution of Atlantic sharpnose shark in the NEFSC spring and autumn surveys from 1963-1999.

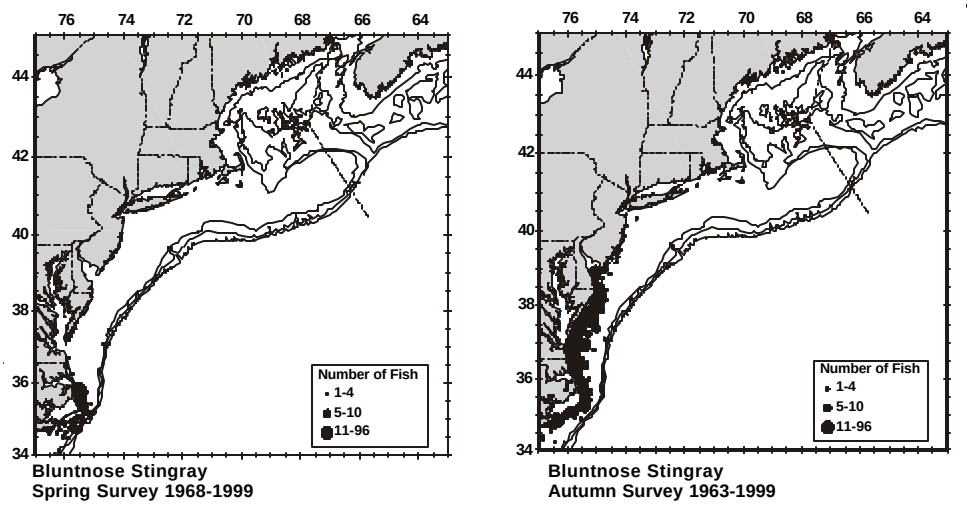

Figure 8. Distribution of bluntnose stingray in the NEFSC spring and autumn surveys from 1963-1999.

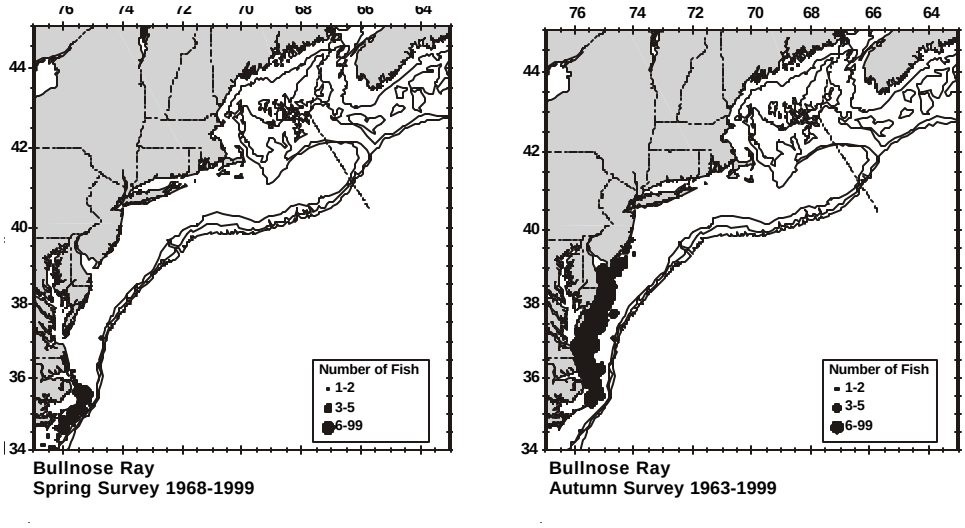

Figure 9. Distribution of bullnose ray in the NEFSC spring and autumn surveys from 1963-1999.

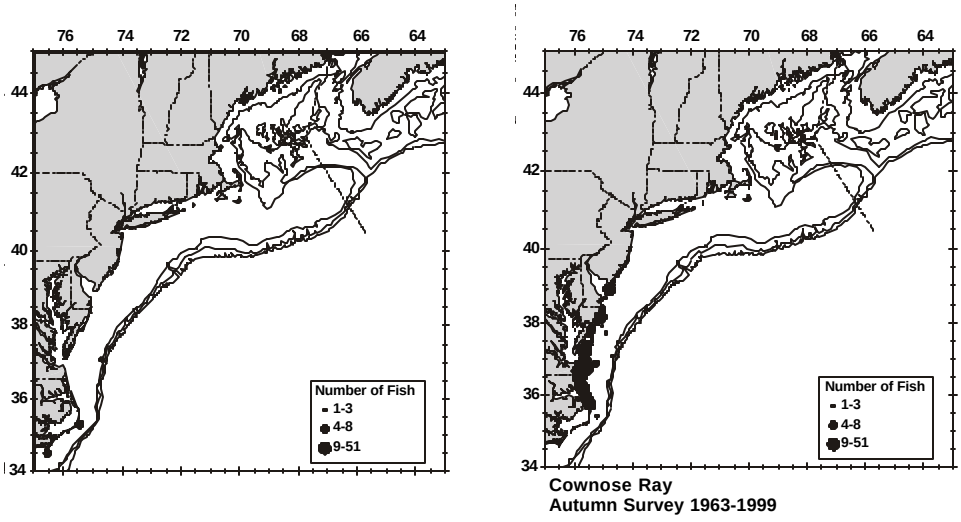

Figure 10. Distribution of cownose ray in the NEFSC spring and autumn surveys from 1963-1999.

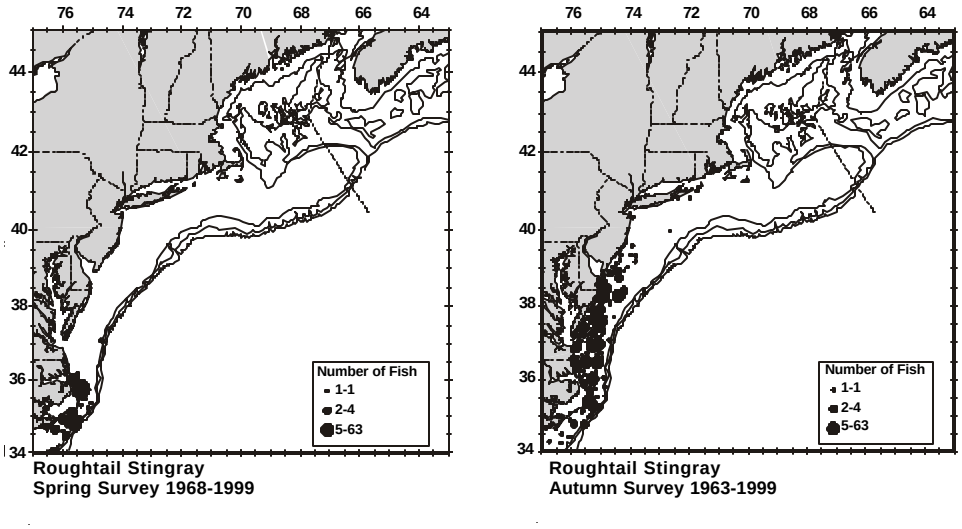

Figure 11. Distribution of roughtail stingray in the NEFSC spring and autumn surveys from 1963-1999.

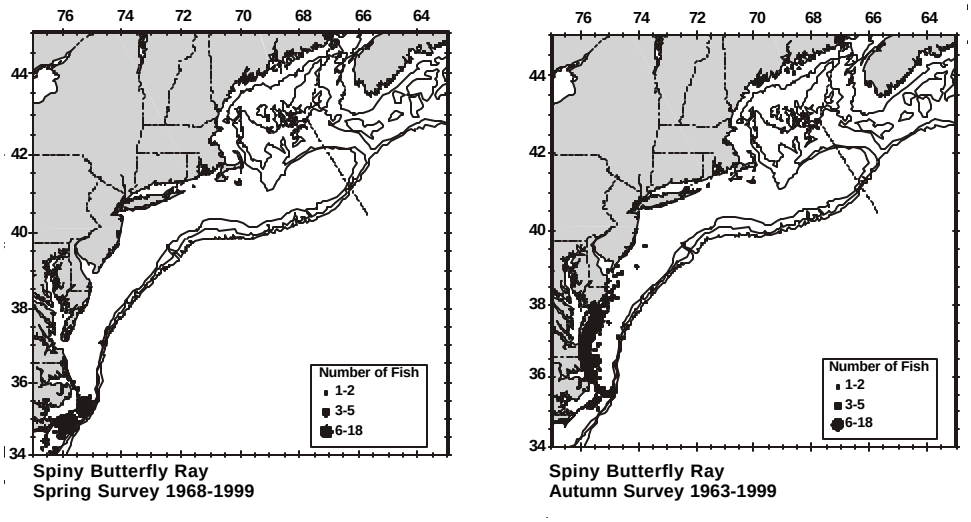

Figure 12. Distribution of spiny butterfly ray in the NEFSC spring and autumn surveys from 1963-1999.

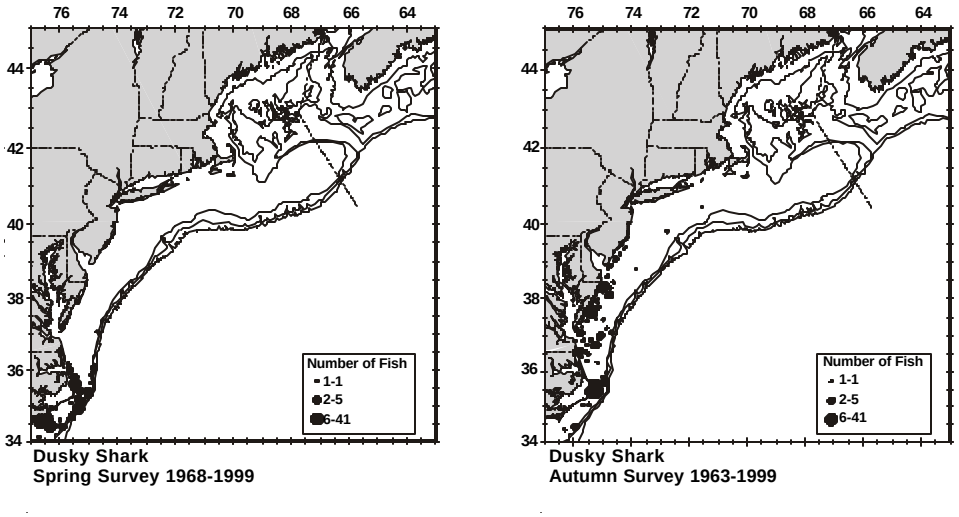

Figure 13. Distribution of dusky shark in the NEFSC spring and autumn surveys from 1963-1999.

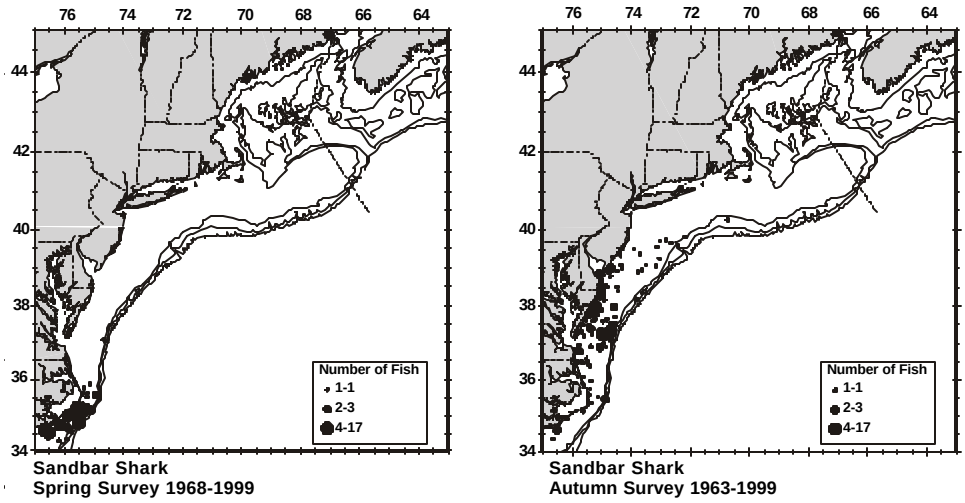

Figure 14. Distribution of sandbar shark in the NEFSC spring and autumn surveys from 1963-1999.

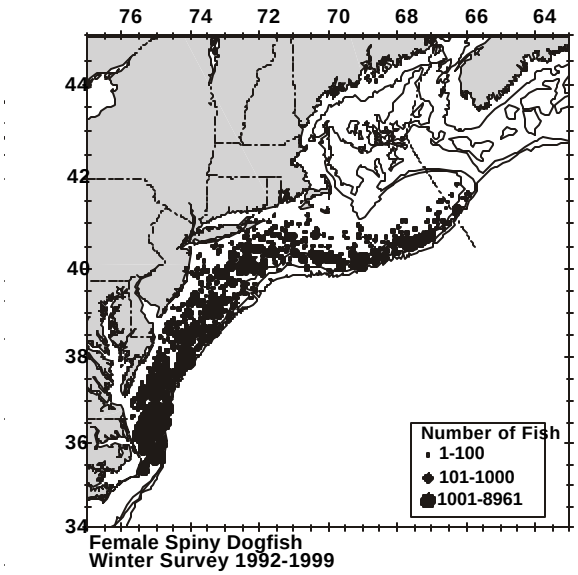

Figure 15. Distribution of female spiny dogfish in NEFSC winter surveys, 1992-1999.

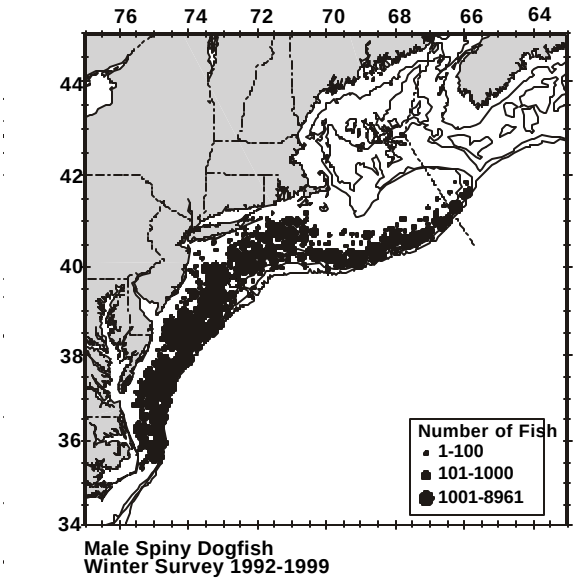

Figure 16. Distribution of male spiny dogfish in NEFSC winter surveys, 1992-1999.

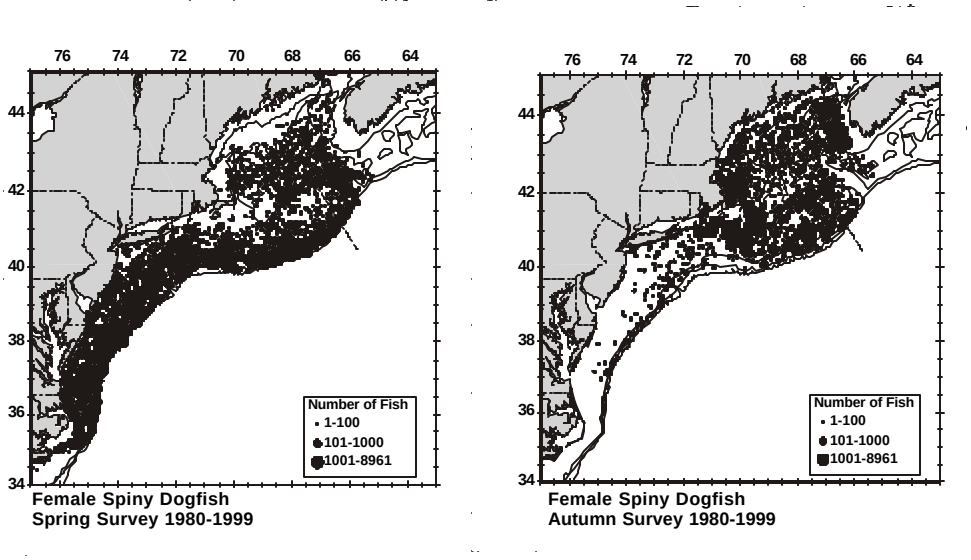

Figure 17. Distribution of female spiny dogfish in the NEFSC spring and autumn surveys from 1980-1999.

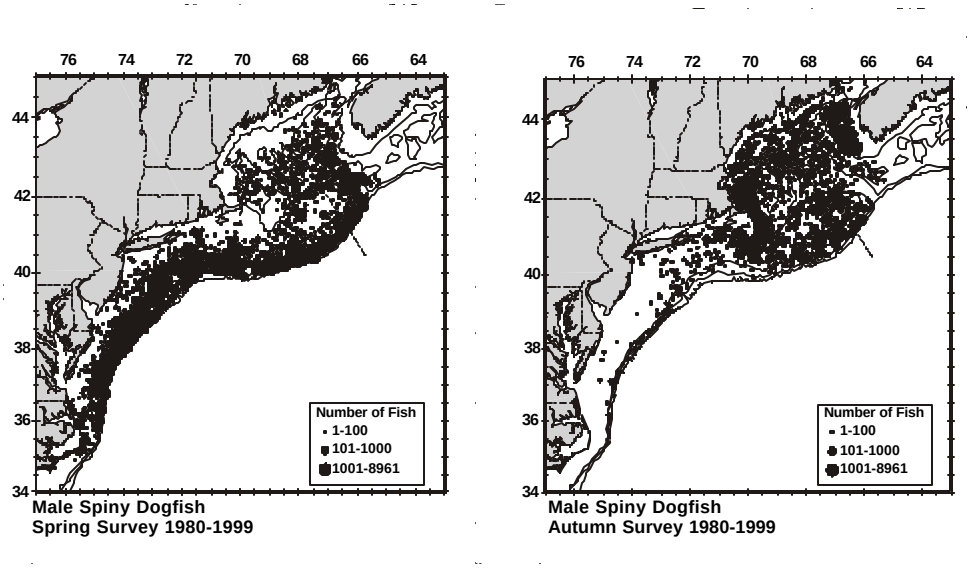

Figure 18. Distribution of male spiny dogfish in the NEFSC spring and autumn surveys from 1980-1999.

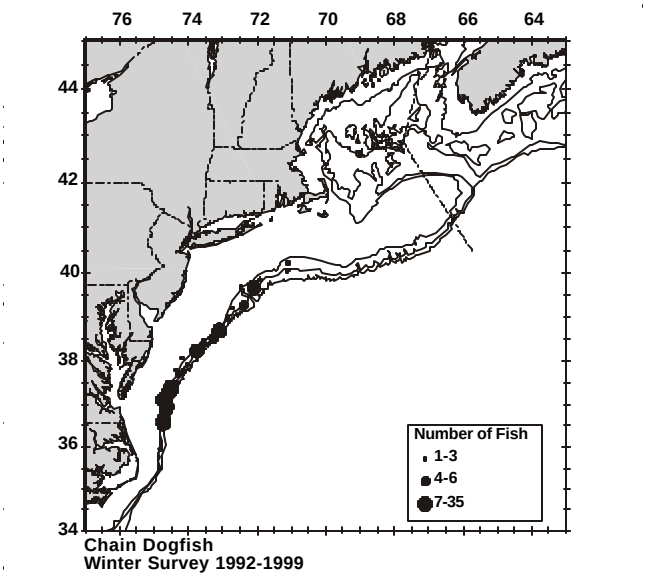

Figure 19. Distribution of chain dogfish in NEFSC winter surveys, 1992-1999.

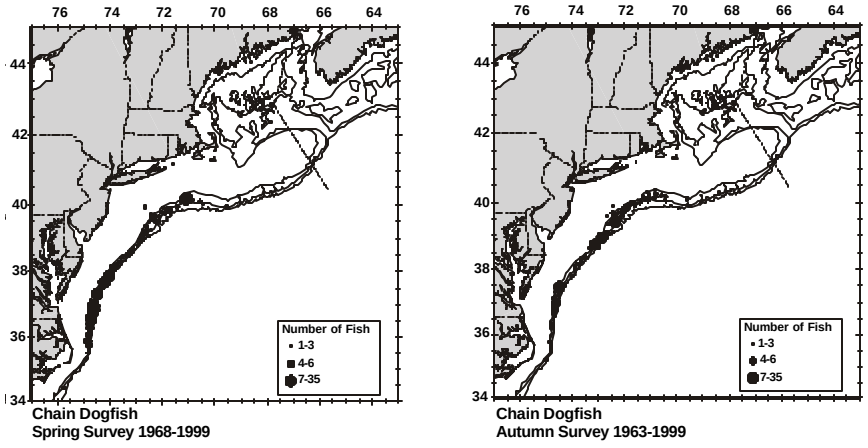

Figure 20. Distribution of chain dogfish in the NEFSC spring and autumn surveys from 1963-1999.

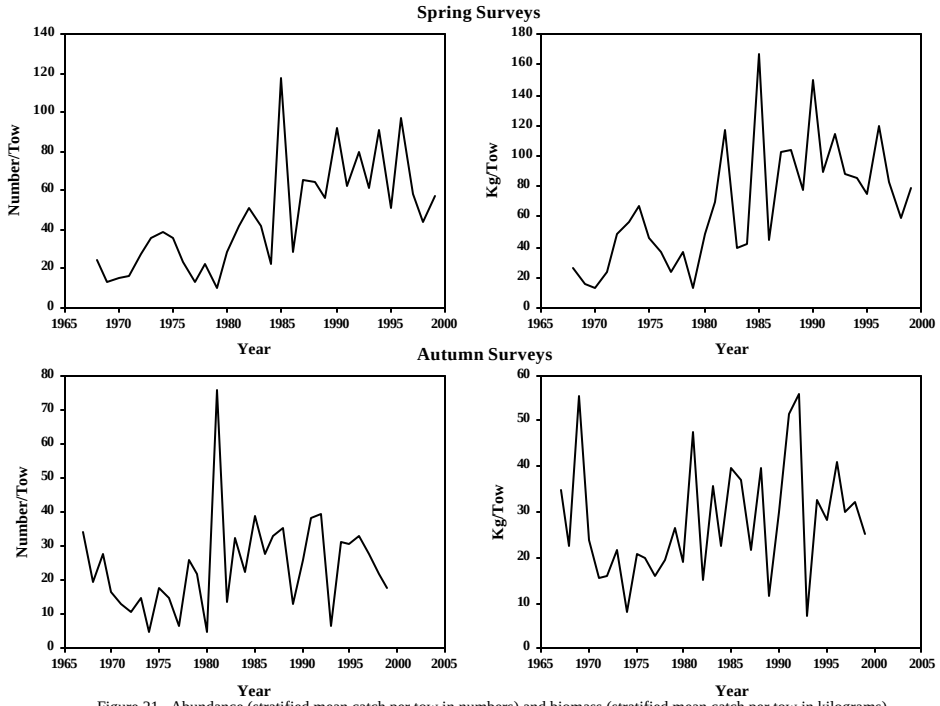

Figure 21. Abundance (stratified mean catch per tow in numbers) and biomass (stratified mean catch per tow in kilograms) indices of spiny dogfish from the NEFSC spring survey, 1968-1999, and autumn survey, 1967-1999 (Offshore strata 1-30, 33-40, 61-76).

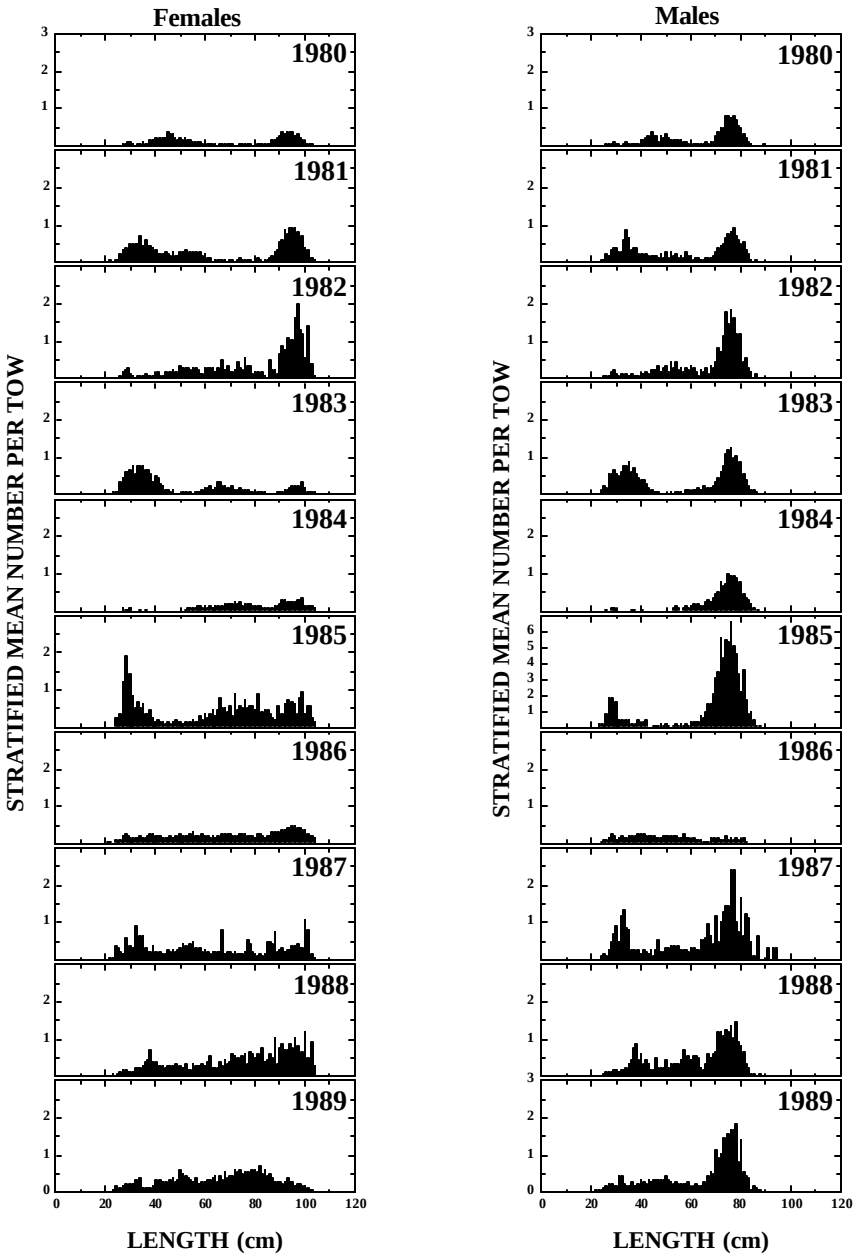

Figure 22. Length composition of male and female spiny dogfish from the NEFSC spring bottom trawl surveys, 1980-1989 (Offshore strata 1-30, 33-40, 61-76). Note the scale for males in 1985 is larger.

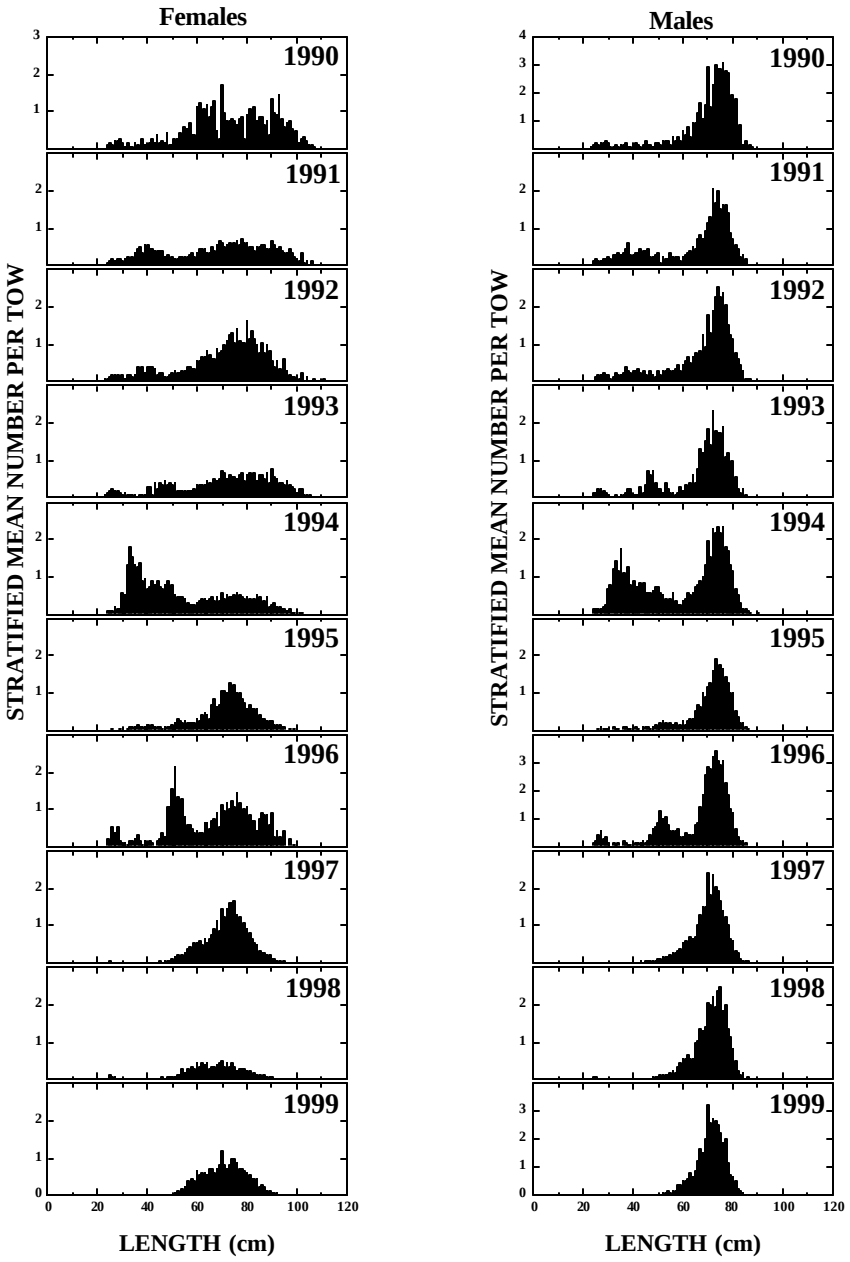

Figure 23. Length frequency composition of male and female spiny dogfish from NEFSC spring surveys, 1990-1999 (Offshore strata 1-30, 33-40, 61-76). Note the scales for males in 1990, 1996, and 1999 are different.

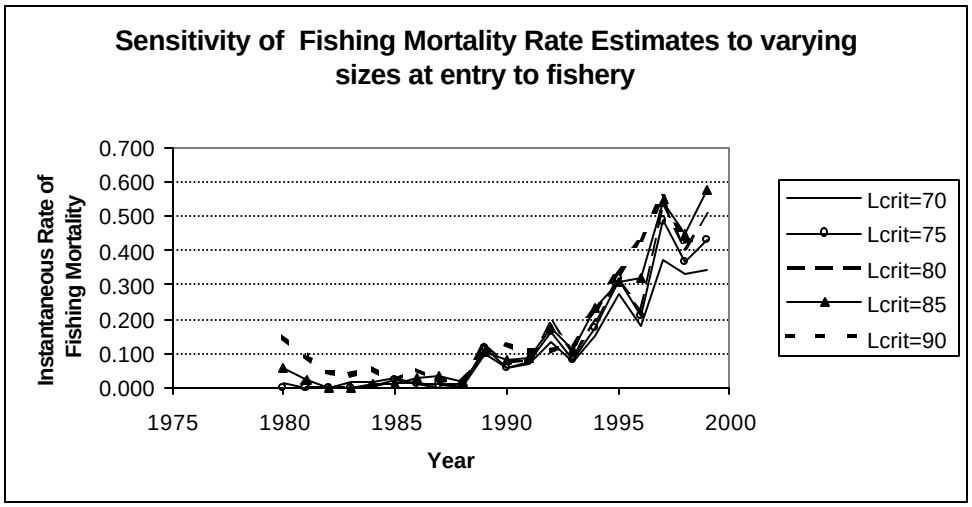

Figure 24. Sensitivity of fishing mortality estimates using varying sizes at entry to the fishery