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Maturity of Skates in Northeast United States Waters

(Elasmobranch Fisheries – Poster)

by

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Abstract

There are few studies on the life history of most skate species, including the seven residents off the Northeast coast of the United States. Assumptions have been made on longevity, growth rate, and maturity based on body size and relationships developed from a few studied species. In the present study observations on the maturity of seven species of skate in the Northwest Atlantic were made on research surveys from 2000-2002. These observations consisted of measurements of body morphometry (clasper length and cloaca length) for which the allometric growth rates change with maturity. A technique primarily used in crustacean biology was employed to estimate the size at first maturity. Values of size at first maturity ranged from 33 cm for male rosette skate to 105 cm for female barndoor skate.

Introduction

The seven species in the USA Northeast Region (Maine to Virginia) skate complex are distributed along the coast of the northeast United States from the intertidal zone to depths exceeding 700 m (Collette and Klein-MacPhee, 2002). The species are: little skate (*Leucoraja erinacea*), winter skate (*L. ocellata*), barndoor skate (*Dipturus laevis*), thorny skate (*Amblyraja radiata*), smooth skate (*Malacoraja senta*), clearnose skate (*Raja eglanteria*), and rosette skate (*L. garmani*).

In the Northeast region, the center of distribution for the little and winter skates is Georges Bank and Southern New England (NEFSC, 2000). The barndoor skate is most common in the Gulf of Maine, on Georges Bank, and in Southern New England. Thorny and smooth skates are commonly found in the Gulf of Maine. Clearnose and rosette skates have a more southern distribution, and are found primarily in Southern New England and the Chesapeake Bight. Skates are not known to undertake large-scale migrations (Templeman, 1984), but they do move seasonally in response to changes in water temperature, moving offshore in summer and early autumn and returning inshore during winter and spring.

The life histories of many of these species of skates are not well known. Some age studies have been accomplished on little, winter, and clearnose skate (Fitz, 1956; Daiber, 1960; Fitz and Daiber, 1963, Johnson, 1979; Waring, 1984; Simon and Frank, 1996, Gelsleichter, 1998). Maturity of the thornback ray (*Raia clavata*) in the northeastern Atlantic was examined using measurements of reproductive organs (clasper length and cloaca length; Steven, 1934). Some studies have used stages to estimate maturity (del Rio and Junquera, 2000). Frisk *et al*. (2001) compiled a summary of available life history parameters for skate species from around the world, and developed predictive relationships between total length (L_{max}) and length of maturity (L_{mat}) and age of maturity (A_{mat}).

In 1999, the National Marine Fisheries Service was petitioned to list barndoor skate as endangered based on a paper by Casey and Myers (1998). A non-lethal method for determining size of first maturity was needed to limit the mortality on barndoor skate. The method was applied in the present study to the seven species of skates. Size at first maturity was

then determined using a morphometric technique developed in crustacean biology to find the length where the allometric growth of the reproductive organs changes.

Methods

The seven species of skates were sampled on the Northeast Fisheries Science Center (NEFSC) research bottom trawl surveys and scallop dredge surveys during 2000-2002. The trawl surveys are conducted in three seasons: winter (February), spring (March-April) and autumn (September-October) (Azarovitz, 1981). The spring and autumn surveys cover the region from Cape Hatteras, NC through the Gulf of Maine. The winter survey covers the region from Cape Hatteras, NC to Georges Bank and has a much higher catchability for skates due to the configuration of the gear (NEFSC 2000). The NEFSC scallop dredge survey is conducted in the summer (July-August). The scallop dredge survey covers the region from Cape Hatteras, NC to Georges Bank but does not cover inshore areas, depths greater than 150 meters, or the shallow portions of Georges Bank. Additional samples for some of the species were taken on the Monkfish Cooperative Industry survey in March and April of 2001. Sampling was conducted on this cooperative survey through the entire northeast region with many stations in waters greater than 200 meters (NEFSC 2002).

For all skates measurements of total length (TL, rostrum to tip of tail) were made to the nearest cm. For males, clasper length (CLM) was measured as the length from the posterior portion of the cloacal opening to the tip of the clasper (Fig. 1). Cloaca length (CLF) was measured in females as the length from the cloacal opening to the anterior end of the cloaca (Fig. 2). Both measurements were made to the nearest mm.

To determine the size at first maturity, the data were examined using a method developed for crustacean maturity (Somerton, 1980). Both length and CLF/CLM were log-transformed and the data were then sorted by length. When plotted against each other, an inflection point where two lines having different slopes intersect can be seen (barndoor males, Fig. 5). To determine the point where the two lines meet, it is necessary to run two linear regressions. Beginning with the second data point, the data were split into two subsets, one below that data point (the dataset containing two data points) and the other above (containing the rest of the data). A pair of linear regressions was fit to these subsets of the data and a residual sum of squares calculated. This process was repeated for all the data points, moving the regressions each time (the second pair would have three data points in one regression and one less data point in the second regression). The minimum residual sum of squares represents the inflection point or the size at first maturity.

Results

Barndoor skate were caught mainly in the winter and spring on Georges Bank (Table 1; Fig. 3). Both the increased catchability of the gear used in the winter survey and the addition of samples from the cooperative survey made these two seasons the basis for the maturity analysis. Winter skate were sampled evenly across seasons (Figure 3) and years (Table 1). Clearnose skate were sampled mostly on the winter survey (Table 1; Fig. 3). No clearnose skate were caught in the summer on the scallop survey because clearnose skate are generally in inshore waters during the summer and the scallop survey does not cover inshore waters. Rosette skate were sampled during all seasons, but winter was the primary season of capture (Table 1; Fig. 3). Samples were taken during all seasons for little skate (Table1; Fig. 4). Smooth and thorny skate were sampled primarily during the spring and autumn because the winter survey does not cover the Gulf of Maine, which is the center of distribution for these two species (Table1; Fig. 4).

The measurements collected were more consistent for males than for females in all species (Fig. 5-8). There is a lot more flexibility in measuring the cloaca than in measuring the clasper and this may lead to greater variability in the measurements. An inflection point is evident in the data for the males of each species, but this is less obvious in the data for females because of the greater variability.

The size at first maturity for barndoor skate females ranged from 96 cm to 105 cm (Table 2; Fig. 9). The data for males was less variable and the size was estimated to be 100 cm. (Table 2; Fig. 9). Winter skate was the only species for which there was a range in the minima of the residual sum of squares for males (Fig. 9). This gave a range in size at first maturity of 53cm to 58 cm (Table 2). Females began to mature at a much larger size of 66 cm to 73 cm (Table 2; Fig. 9). Clearnose skate males began to mature at a size of 56 cm with females maturing at slightly larger size of 59 cm to 65 cm (Table 2; Fig. 10). Rosette skate matured at the smallest size, with males maturing at 33 cm and females at about the same size (33-35 cm;

Table 2; Fig. 10). Little skate males began maturing at a size of 39 cm with females maturing at a slightly larger size between 40 and 48 cm (Table 2: Fig. 11). Smooth and thorny skate were the two species for which females matured at a smaller size than males (Table 2; Fig. 11 and 12).

Discussion

Comparison of the sizes at first maturity with those from Frisk *et al*. (2001) predictive equation cited in NEFSC (2000) reveals that the estimates from this study are generally lower. Since the predictive equation estimates size at 50% maturity, the lengths from this study should be smaller. The only value that is considerably different is for thorny skate. This may be due to maturation over a large size range that appears to occur in this species. However, a length of 50 cm agrees well with other estimates from Canadian waters (Templeman, 1982; Simon and Frank, 1996).

The regression technique generally performed better for males than for females in all species. Females generally displayed two possible minima, indicating that maturity may take place over a larger length range than for males or there is much more measurement error. The elasticity of the cloaca also introduces more variability than the measurement of the clasper. Steven (1934) did not find as much variability in measurements of the cloaca as was found in this study. The blunt tool used by Steven (1934) to measure the cloaca may have provided better measurements compared to the sharp-ended calipers used in the present study that easily penetrated the cloaca.

For some of the species there is also a problem with species identification. In particular, little and winter skate are very easily misidentified. This may be why male winter skates seem to mature over a size range rather than at a single size as in the other species. Smooth and thorny have also been misidentified, particularly at small sizes. This may contribute to the variance seen in those two species.

The variation seen in female maturation may reflect a need for auxiliary information on maturity stages. The regression method may provide some guidance as to the size at first maturity, but using actual maturity stages should provide a better metric for size at maturity. However, at this time, there is no way of staging female maturity without sacrificing the animal.

There may be a distinction between morphometric maturity and functional maturity. In some crab species, female morphometric maturity occurs before functional or ovarian maturity (Fernandez-Vergaz *et al*., 2000). This means that morphometric maturity will underestimate the size at maturity. In skates, however, the opposite may be true. Since the length of the cloaca probably changes after copulation or egg deposition, ovarian maturity may occur before morphometric maturity.

This regression technique works well when there is a change in slope at a particular inflection point. However, if there is overlap between mature and immature, it may not work as well (Somerton, 1980). Some of the male skate species, in particular thorny, do exhibit this overlap. Thorny skate appear to mature over a very wide length interval. The minimum size at maturity may be 50 cm, but many do not appear to mature until a much larger size (Fig. 8). This results in a second minimum appearing at a larger size. Somerton (1980) has a second method that may be useful for the future.

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Table 1. Number of skates sampled by species, year, sex and season.

		Winter		Spring		Summer		Autumn		Total	
		M	F	M	F	M	F	M	F	M	F
Barndoor	2000	42	22	14	13	8	5	7	8	71	48
	2001	45	36	80	63	14	11	21	151	131	
	2002	50	40	14	11				64	51	
	Total	137	98	108	87	22	16	19	29	286	230
Winter	2000	143	89	198	168	82	89	100	132	523	478
	2001	161	140	114	117	75	105	131	186	481	548
	2002	74	89	68	130				142	219	
	Total	378	318	380	415	157	194	231	318	1146	1245
Clearnose	2000	186	207	46	61	-	-	25	40	257	308
	2001	136	154	41	27	-	-	104	79	281	260
	2002	93	85	23	12				116	97	
	Total	415	446	110	100	-	-	129	119	654	665
Rosette	2000	89	84	4	7	9	1	5	2	107	94
	2001	118	153	11	7	13	5	8	14	150	179
	2002	53	50	1	2				54	52	
	Total	260	287	16	16	22	6	13	16	311	325
Little	2000	280	241	361	409	309	312	109	153	1059	1115
	2001	336	312	288	320	262	402	144	224	1030	1258
	2002	128	160	246	249				374	409	
	Total	744	713	895	978	571	714	253	377	2463	2782
Smooth	2000	-	3	9	10	6	5	29	20	44	38
	2001	2	8	72	85	11	8	38	29	123	130
	2002	-	2	36	31				36	33	
	Total	2	13	117	126	17	13	67	49	203	201
Thorny	2000	2	-	22	22	3	2	34	30	61	54
	2001	2	2	87	101	3	10	26	30	118	143
	2002	1	-	28	28				29	28	
	Total	5	2	137	151	6	12	60	60	208	225

Table 2. Size at first maturity for seven skate species by sex.

Species	Males	Females
Barndoor	100	96-105
Winter	53-58	66-73
Clearnose	56	59-65
Rosette	33	33-35
Little	39	40-48
Smooth	50	33-48
Thorny	50	43-46

Fig. 1. Measurement of clasper length in male skates.

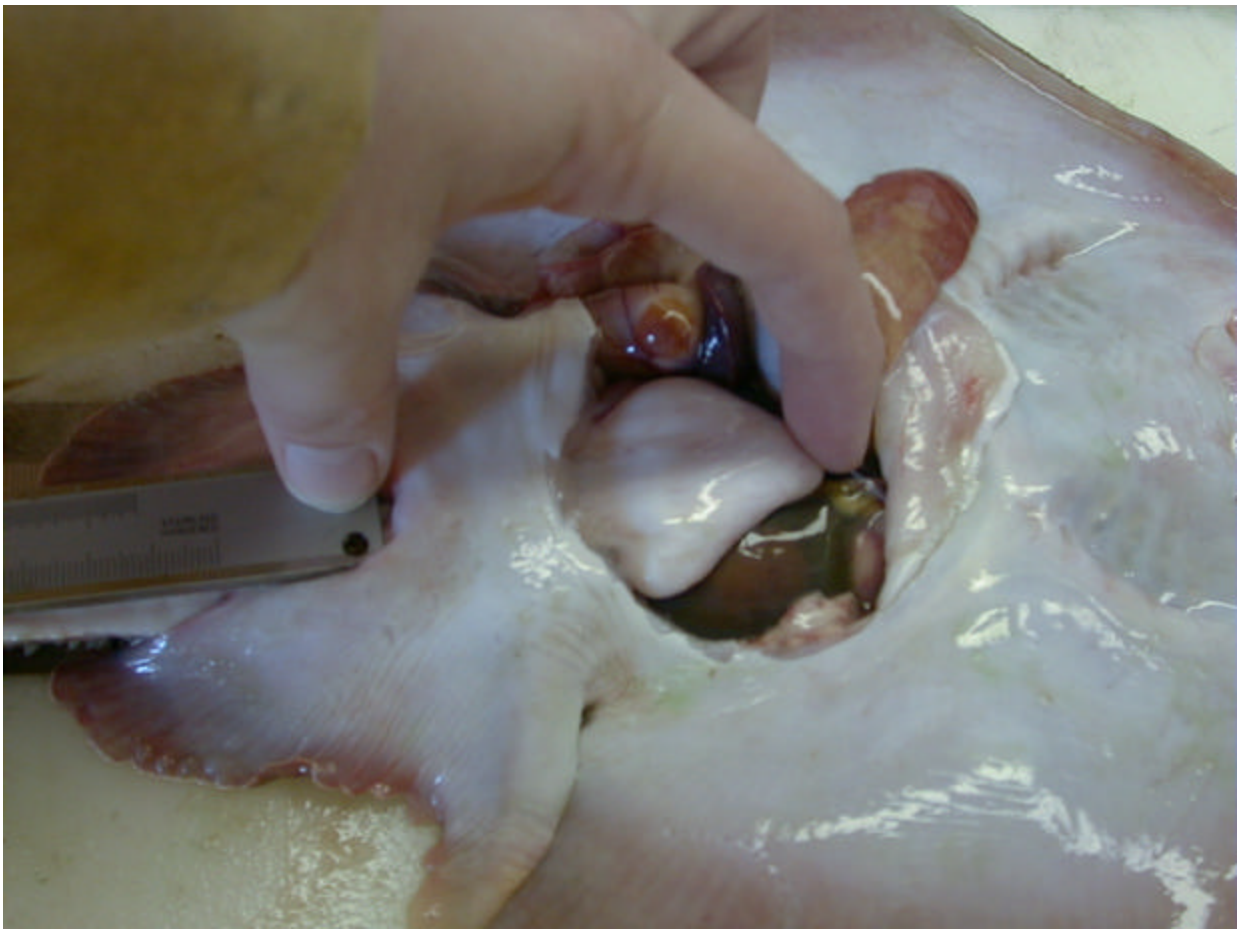

Fig. 2. Measurement of cloaca length in female skates.

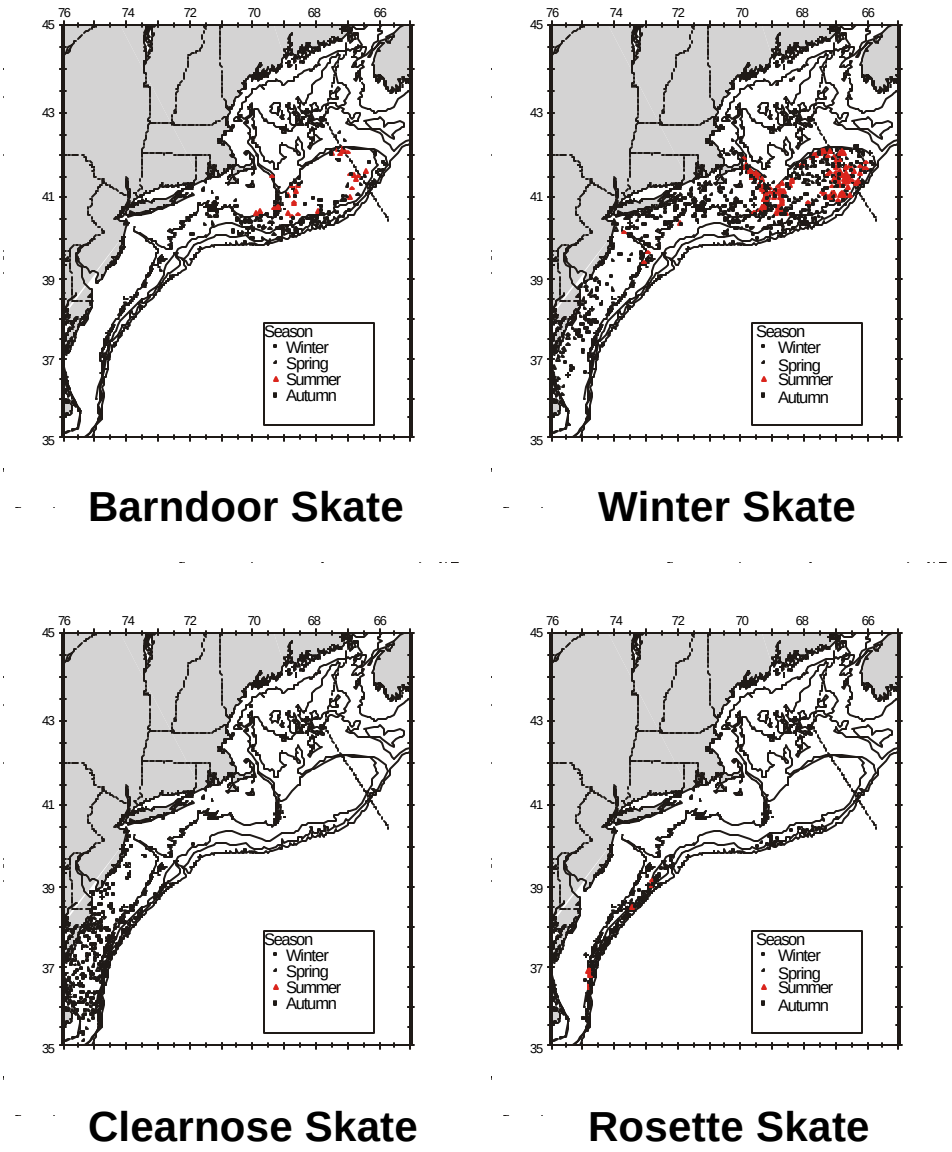

Fig. 3. Location of barndoor, winter, clearnose, and rosette skate sampled during 2000-2002 by season, all years combined.

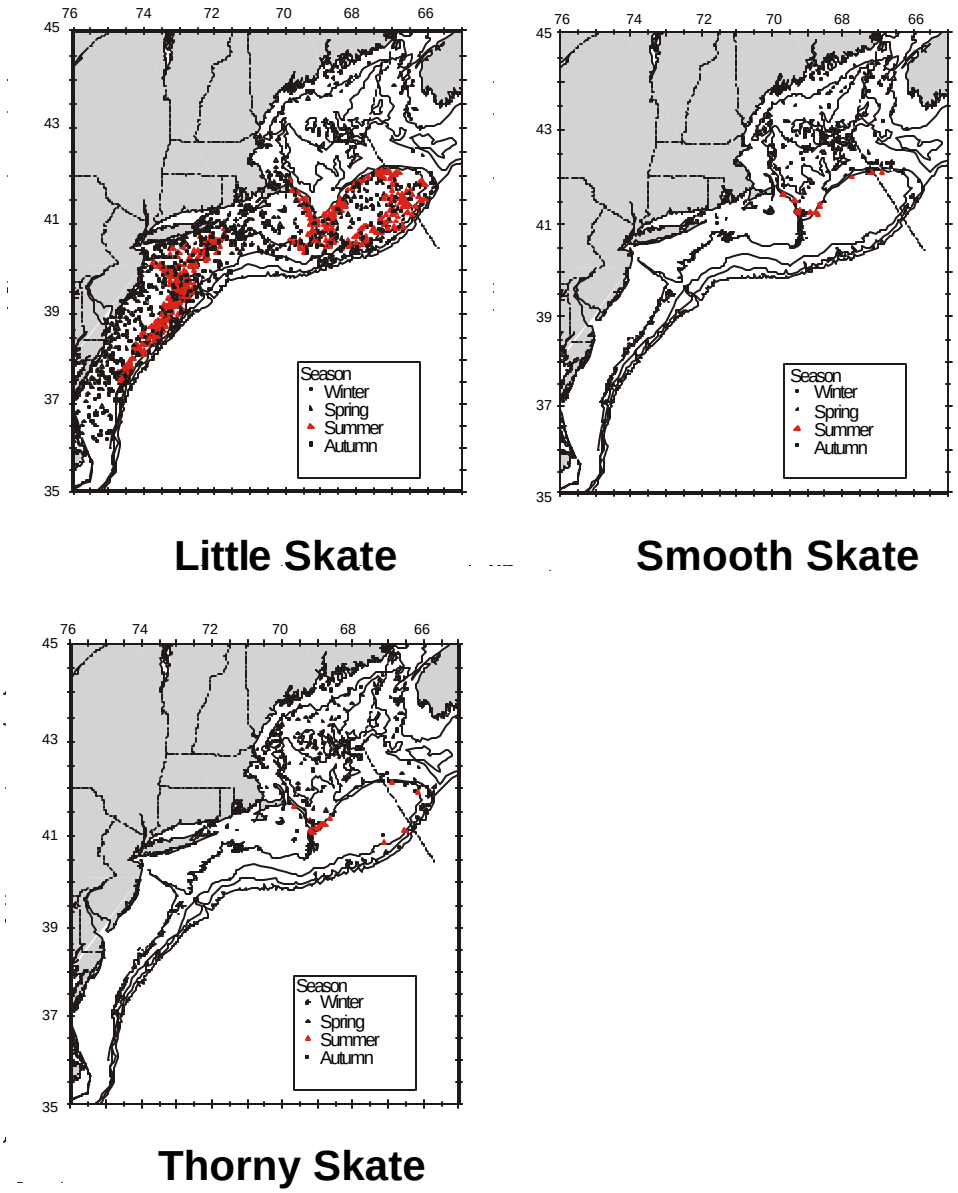

Fig. 4. Location of little, smooth, and thorny skate sampled during 2000-2002 by season, all years combined.

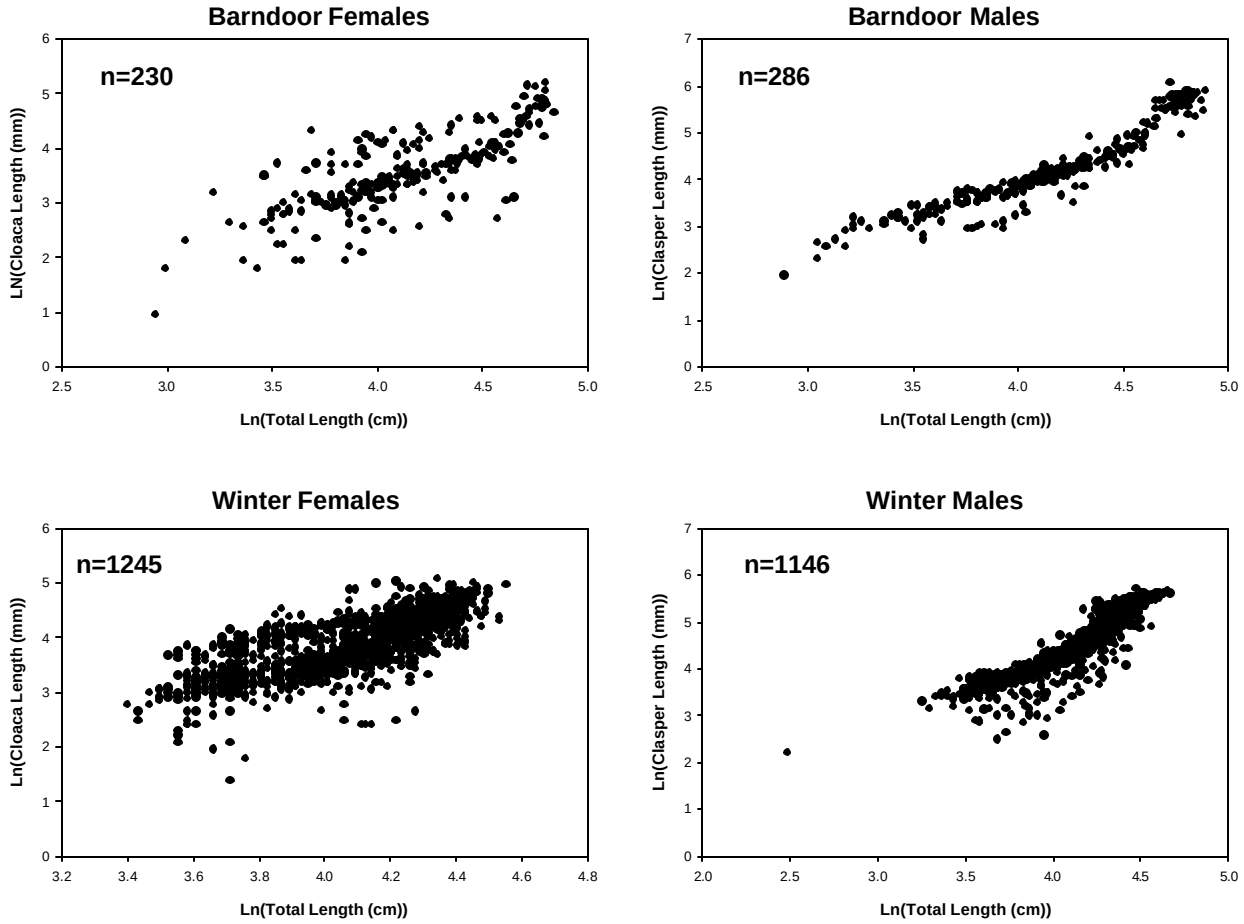

Fig. 5. Clasper length or cloaca length (natural logarithm scale) plotted against total length (natural logarithm scale) for barndoor and winter skates.

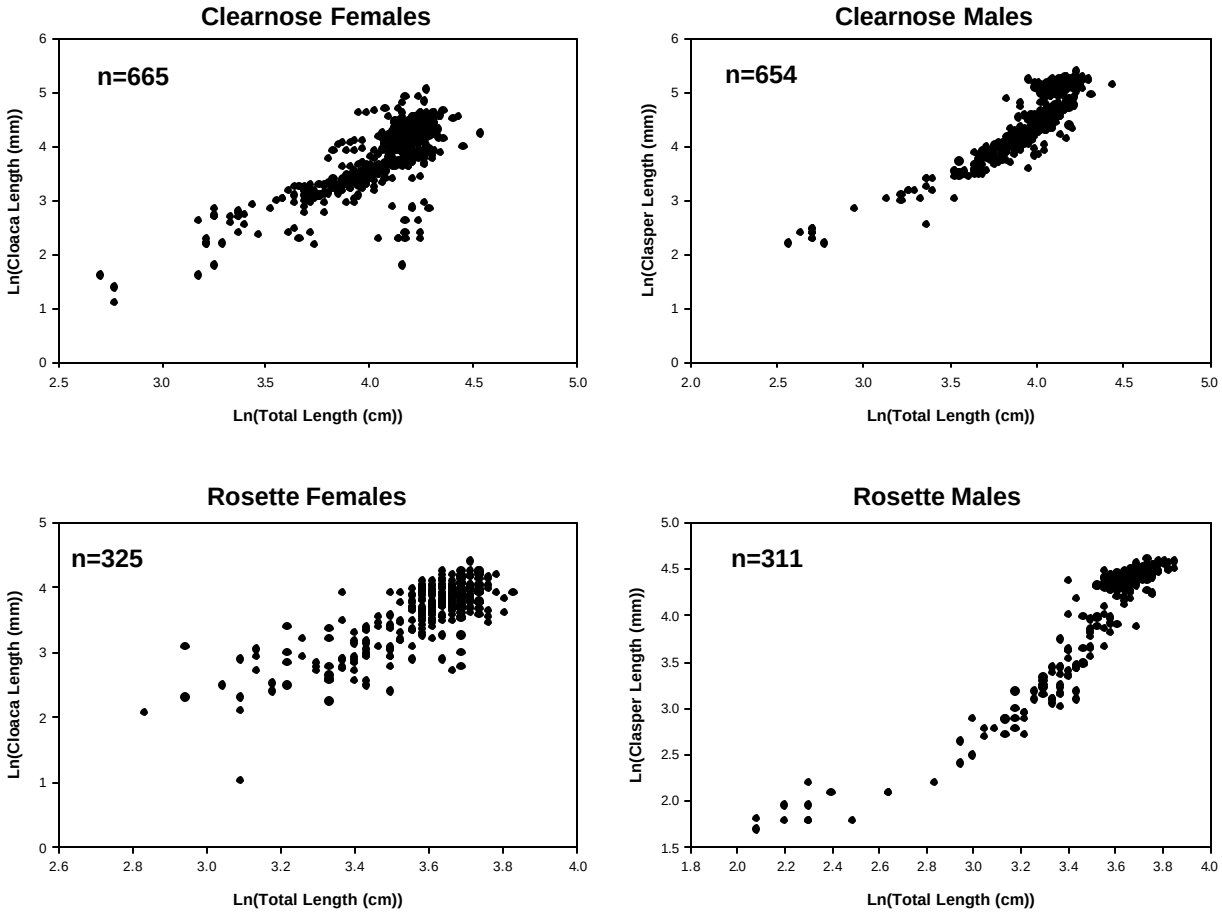

Fig. 6. Clasper length or cloaca length (natural logarithm scale) plotted against total length (natural logarithm scale) for clearnose and rosette skates.

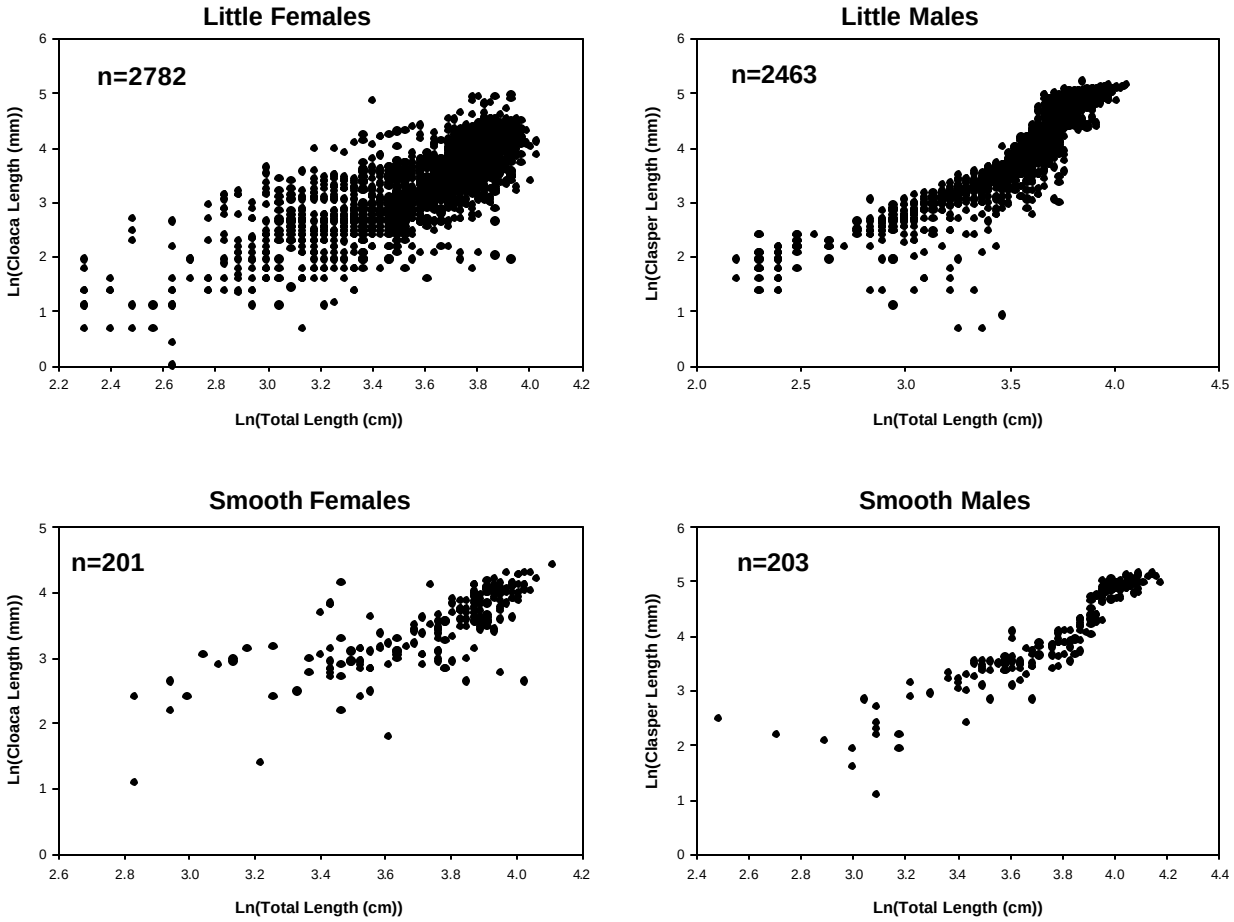

Fig. 7. Clasper length or cloaca length (natural logarithm scale) plotted against total length (natural logarithm scale) for little and smooth skates.

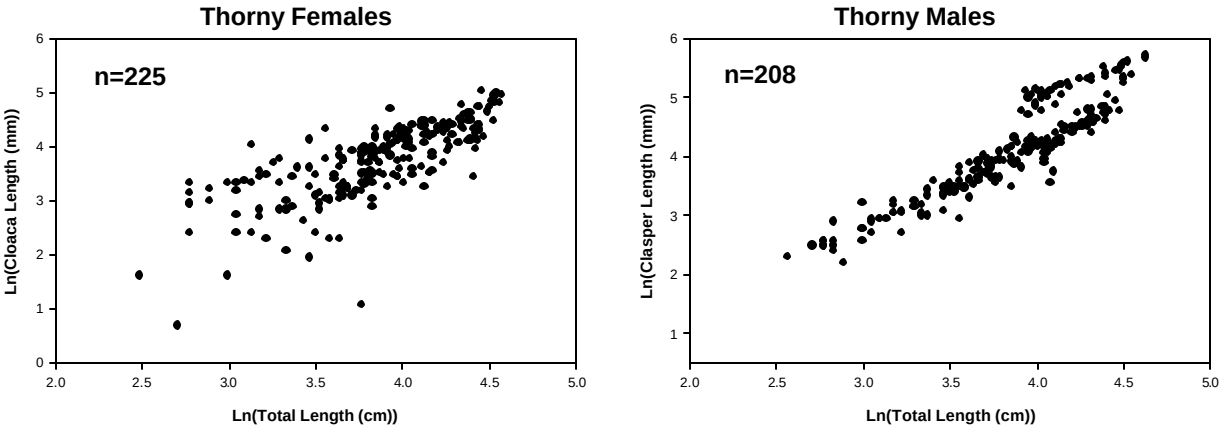

Fig. 8. Clasper length or cloaca length (natural logarithm scale) plotted against total length (natural logarithm scale) for thorny skates.

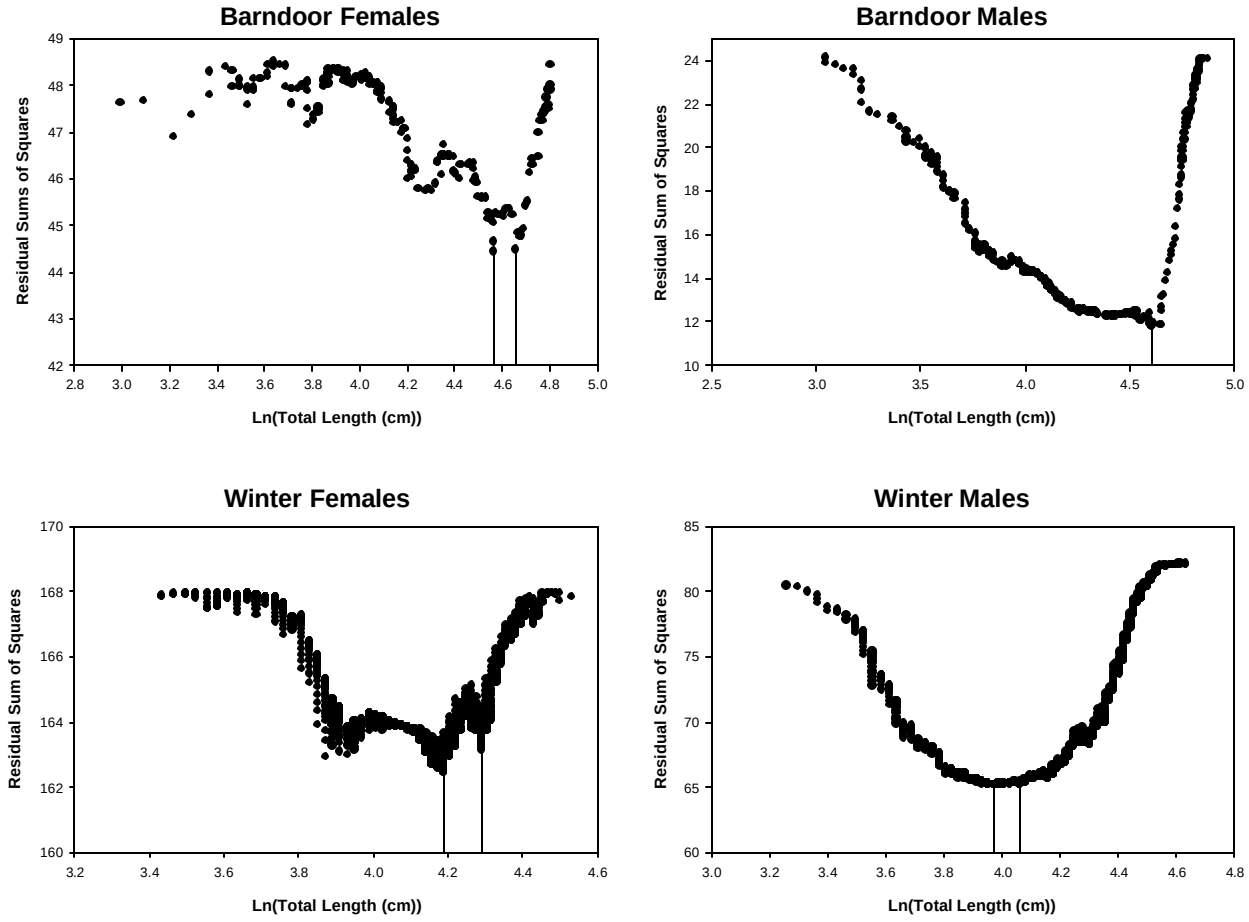

Fig. 9. Residual sum of squares plotted against total length (natural logarithm scale) for barndoor and winter skates. The dropped lines show the location of the size at first maturity or interval for the size at first maturity.

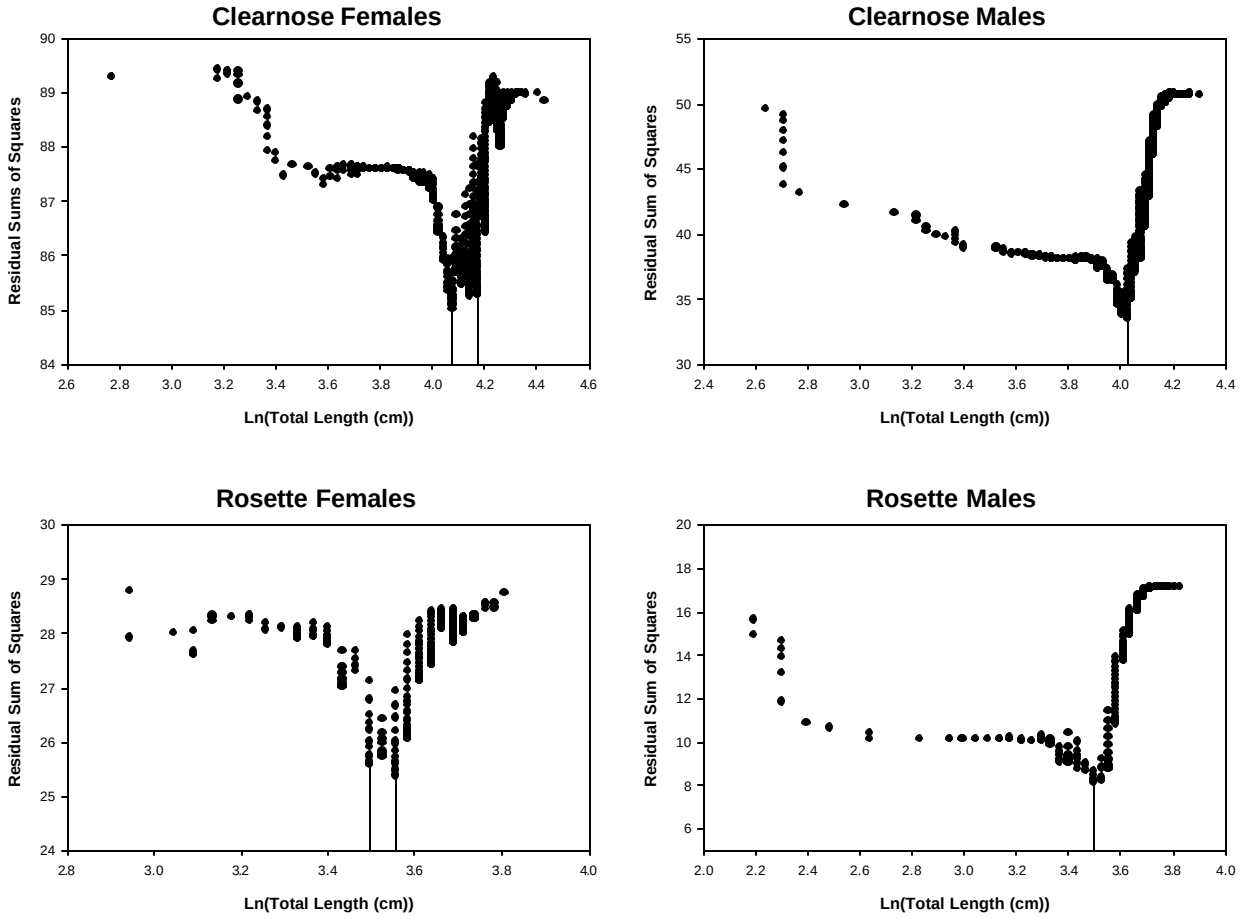

Fig. 10. Residual sum of squares plotted against total length (natural logarithm scale) for clearnose and rosette skates. The dropped lines show the location of the size at first maturity or interval for the size at first maturity.

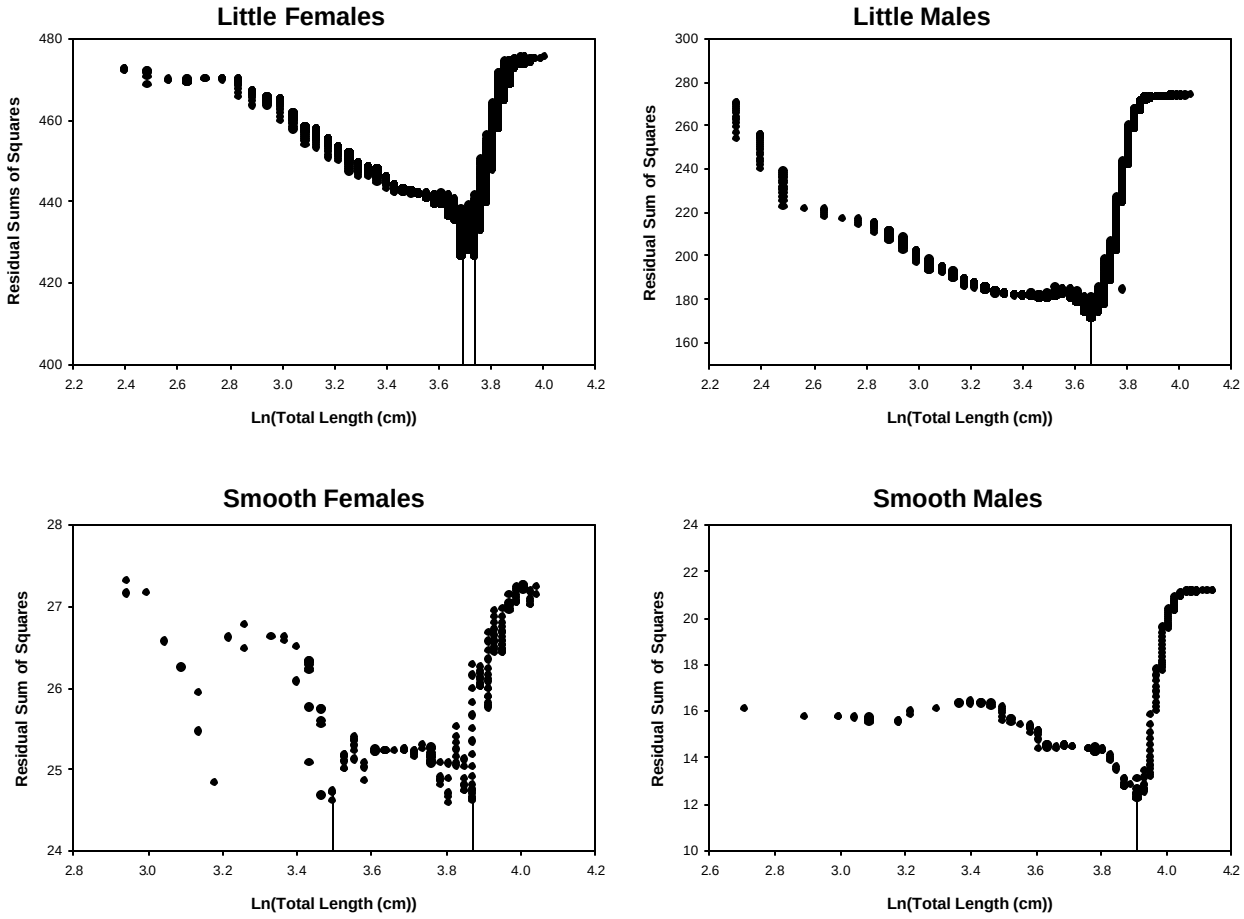

Fig. 11. Residual sum of squares plotted against total length (natural logarithm scale) for little and smooth skates. The dropped lines show the location of the size at first maturity or interval for the size at first maturity.

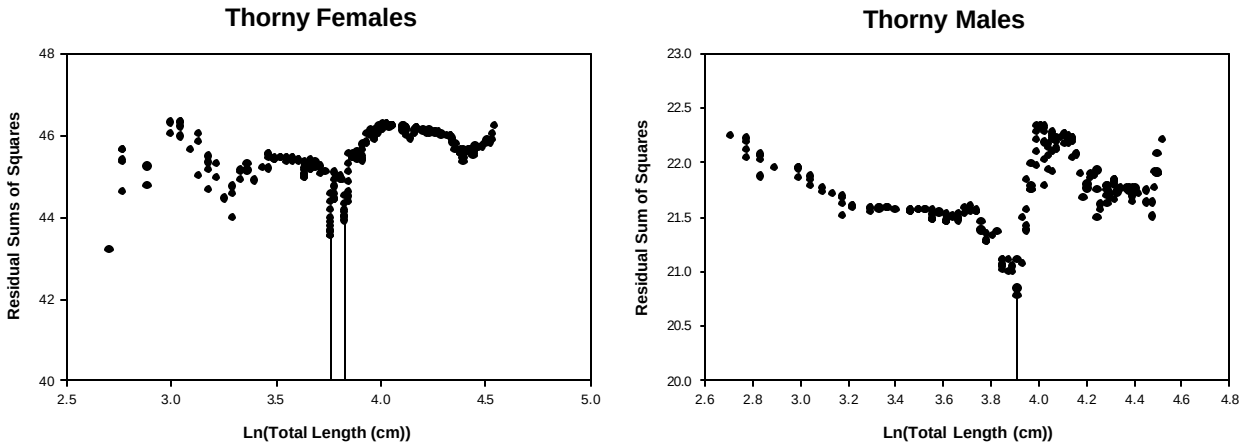

Fig. 12. Residual sum of squares plotted against total length (natural logarithm scale) for thorny skates. The dropped lines show the location of the size at first maturity or interval for the size at first maturity.