

The Status of Skate Stocks in the Barents Sea

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Abstract

Annual trawl surveys conducted by Polar Research Institute of Marine Fisheries and Oceanography (PINRO) in the Barents Sea during 1998–2001 have been used to describe the distribution, habitat (temperature, salinity and depth), size distribution and sex ratio of six species of skates (thorny skate, *Amblyraja radiata*; Arctic skate, *Amblyraja hyperborea*; round skate, *Rajella fyllae*; blue skate, *Dipturus batis*; and spinytail skate, *Bathyraja spinicauda*). The relative biomass and abundance of the five species are presented.

Key words: Barents Sea, depth, distribution, habitat, length, salinity, skates, temperatures

Introduction

Regular assessments of the status of the major commercial demersal fish stocks (cod, haddock, redfish, catfish etc.) in the Barents Sea are made by the Polar Research Institute of Marine Fisheries and Oceanography (PINRO) using trawl surveys undertaken in autumn/winter (Shevelev *et al.*, MS 1990). Historically, these assessments have not been extended to skates, though they are potential targets for commercial fisheries and PINRO has collected data on their distribution and biology since the late-1980s.

Seven species of skate (Rajidae) are listed for the Barents Sea; thorny skate, *Amblyraja radiata*, Arctic skate, *Amblyraja hyperborea*, round skate, *Rajella fyllae*, blue skate, *Dipturus batis*, spinytail skate, *Bathyraja spinicauda*, long-nosed skate, *Dipturus oxyrhynchus*, and shagreen ray, *Leucoraja fullonica* (Andriyashev, 1954). The first five species are the most common, while the latter two were not found in recent surveys (Dolgov, 2000). There are also records of sail ray, *Dipturus linteus*, in the area (Ponomarenko, 1961; Poletaev and Shibanov, 1982; Dolgov and Igashov, 2001). Although thornback ray, *Raja clavata*, are reported from the northern coast of Norway (Hognestad and Vader, 1979), they are scarce in the Barents Sea.

In this paper we review the habitat and distribution of six skate species in the Barents Sea, their size composition and sex ratio and estimate the relative abundance and biomass.

Materials and Methods

Data were collected from annual surveys conducted by PINRO in the Barents Sea from October to December

1998–2001. A standard research bottom trawl (type 2283, 25 × 8 m opening) with a 16 mm mesh cod-end liner was used as the sampling gear (Shevelev *et al.*, MS 1990). Duration of trawling was usually 1 hour. All skate caught were identified to species, measured for total length from the snout to the tip of the caudal fin to the nearest 1 cm, and sexed. In some cases, fish were weighed and biological samples were taken. Water temperature and salinity near the bottom were measured using a CTD system before or after each trawl haul.

The abundance of skates was estimated using the average catch of each species of skate at 5 cm length intervals, calculated from the number of specimens caught in all 1 hour trawl haul divided by the total number of hauls, in each fishing area (Map of fishing areas in the Barents Sea, 1957), multiplied by the area of each fishing area. As there were no specific studies on the fishing efficiency of the research trawl for skates, the fishing efficiency estimated for other fish with a similar body shape and behaviour to skates species, such as flatfish, was used to estimate abundance and biomass (Vinther and Sparholt, MS 1988). The fishing efficiency by the research trawl for thorny skate was estimated by underwater observations to be 5 times less than that for long rough dab (*Hippoglossoides platessoides*) (T. B. Nikiforova and L. I. Serebrov, PINRO, unpubl. data), for which the fishing efficiency was, on average, 0.2. Given the range of sizes in the skate species caught, a value of 0.1 was used for the fishing efficiency of the trawl for all skate species and size groups. The overall relative abundance of each species was the sum of estimates for each individual fishing area.

Biomass was estimated from the sum of numerical abundance of fish in each 5 cm length interval, and the mean weight of fish for each length group provided by survey biological sampling data.

Since the survey area differed slightly between years, only those locations which had been covered by all surveys, were used to derive comparable estimates of abundance and biomass. The total area surveyed was approximately 200 000 naut. miles.

Results

Species composition

Six skate species were recorded in the PINRO surveys in 1998–2001 (Table 1). The most frequent, thorny skate, comprised 95.8% of the total number of skates caught and 91.8% by weight. Arctic and round skates comprised 3.0 and 1.8% by number, respectively, while the other skate species were relatively scarce.

Hydrographic and bathymetric conditions

The hydrographic conditions associated with the various skate species are illustrated in Fig. 1. Arctic skate lived mainly below 0°C, although some individuals were recorded in waters of up to 4°C. Thorny skate occurred over a wide range of temperatures (-1°C to +7.5°C), although it was most abundant at +0.5°C to +3.5°C. Round, blue and spinytail skate were found at higher water temperatures (generally >+2°C), and sail ray was only found at temperatures of +4°C to +6°C. All species of skate occupied the same salinity range, 34.5–35.5‰ and, while salinity variations were generally small (0.19–0.32‰) the range of salinity inhabited by thorny skate varied by 2‰.

TABLE 1. Data on various skate species caught during trawl surveys during 1998–2001.

Year	1998	1999	2000	2001
Number of hauls	409	404	534	422
Thorny skate				
% occurrence in trawls	73.6	73.5	71.0	74.9
Total number caught	2841	2006	2415	2049
Sex ratio (M:F)	1:1.2	1:1.2	1:1.1	1:1.0
Size range (cm)	10–68	10–75	10–62	9–61
Round skate				
% occurrence in trawls	4.6	6.2	7.9	6.6
Total number caught	33	45	54	48
Sex ratio (M:F)	1:0.8	1:0.9	1:0.7	1:1
Size range (cm)	17–55	14–53	10–56	11–72
Arctic skate				
% occurrence in trawls	3.2	5.9	9.0	6.6
Total number caught	22	140	103	30
Sex ratio (M:F)	1:0.8	1:0.4	1:1.2	1:0.2
Size range (cm)	26–72	17–94	15–74	32–105
Blue skate				
% occurrence in trawls	3.7	0.7	2.6	1.4
Total number caught	22	4	8	4
Sex ratio (M:F)	1:1.9	0:1	1:3.0	1:0.3
Size range (cm)	30–155	84–160	30–106	96–149
Spinytail skate				
% occurrence in trawls	0	1.2	1.9	1.7
Total number caught	0	7	16	7
Sex ratio (M:F)		1:0.2	1:4.3	1:2.5
Size range (cm)		28–182	29–162	33–62
Sail ray				
% occurrence in trawls	0.5	–	–	0.7
Total number caught	2	–	–	3
Sex ratio (M:F)	1:			1:
Size range (cm)				

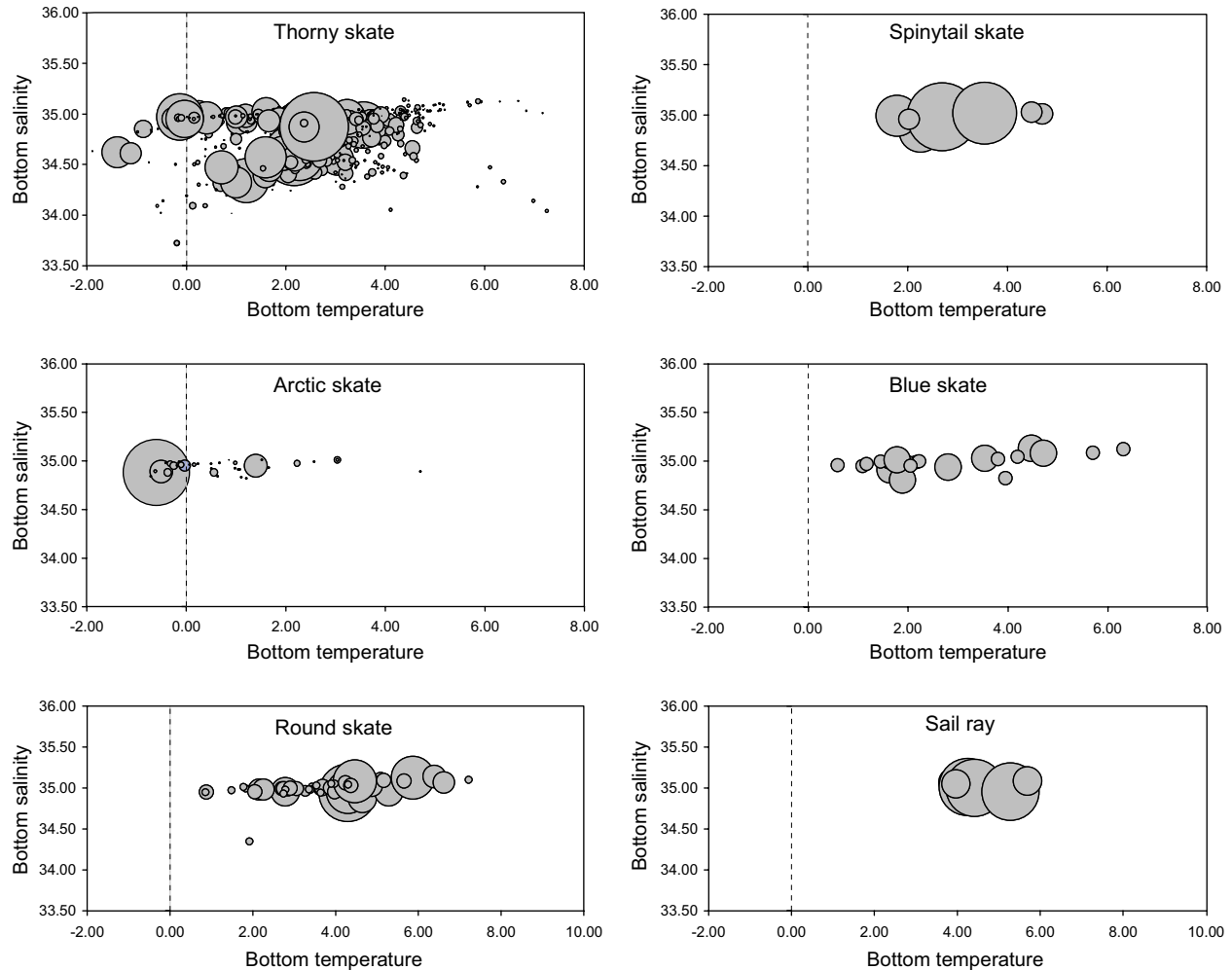


Fig. 1. Hydrographic conditions in the habitat of various skate species in the Barents Sea (the bubbles size corresponds to catch in term on specimen number per 1 hour trawling; scales are different for each species).

Distinct differences in the depth preferences in various skate species were observed (Fig. 2). Thorny skate occurred at depths from <50 m to 800 m, the largest catches were taken at 100–300 m and the catches decreased in deeper water. Round skate also occurred at a wide depth range and catches increased with water depth up to 300 m, below which they were similar. Other skate species, especially Arctic skate, occurred at depths of >200–250 m and their catches also increased with increasing depth.

Distribution

Thorny skate was found over the entire surveyed area of the Barents Sea and in adjacent waters, from Novaya Zemlya in the east to the west coast of Spitsbergen in the northwest (Fig. 3). Annual mean catches of this species were 3.1–4.1 fish per hour and the maximum catch was 110 fish per hour. The largest aggregations of thorny skate occurred in the central and coastal areas of the

southern Barents Sea, and this species was least abundant in the western and eastern areas and around Bear Island – Spitsbergen.

Round skate was found mainly along the coast of Norway and Murman as far north as Bear Island (Fig. 4) and along the west coast of Spitsbergen. Annual mean catches of this species were 0.02–0.03 fish per hour with a maximum catch rate of 5 fish per hour.

Arctic skate was found along the continental shelf slope between the coast of Norway and Bear Island and in the north-eastern part of the surveyed area (Fig. 5). Annual mean catches of this species were 0.1–1.0 fish per hour, maximum catch was 83 fish per hour.

Blue skate, spinytail skate and sail ray were found as single individuals, mainly along the continental shelf from

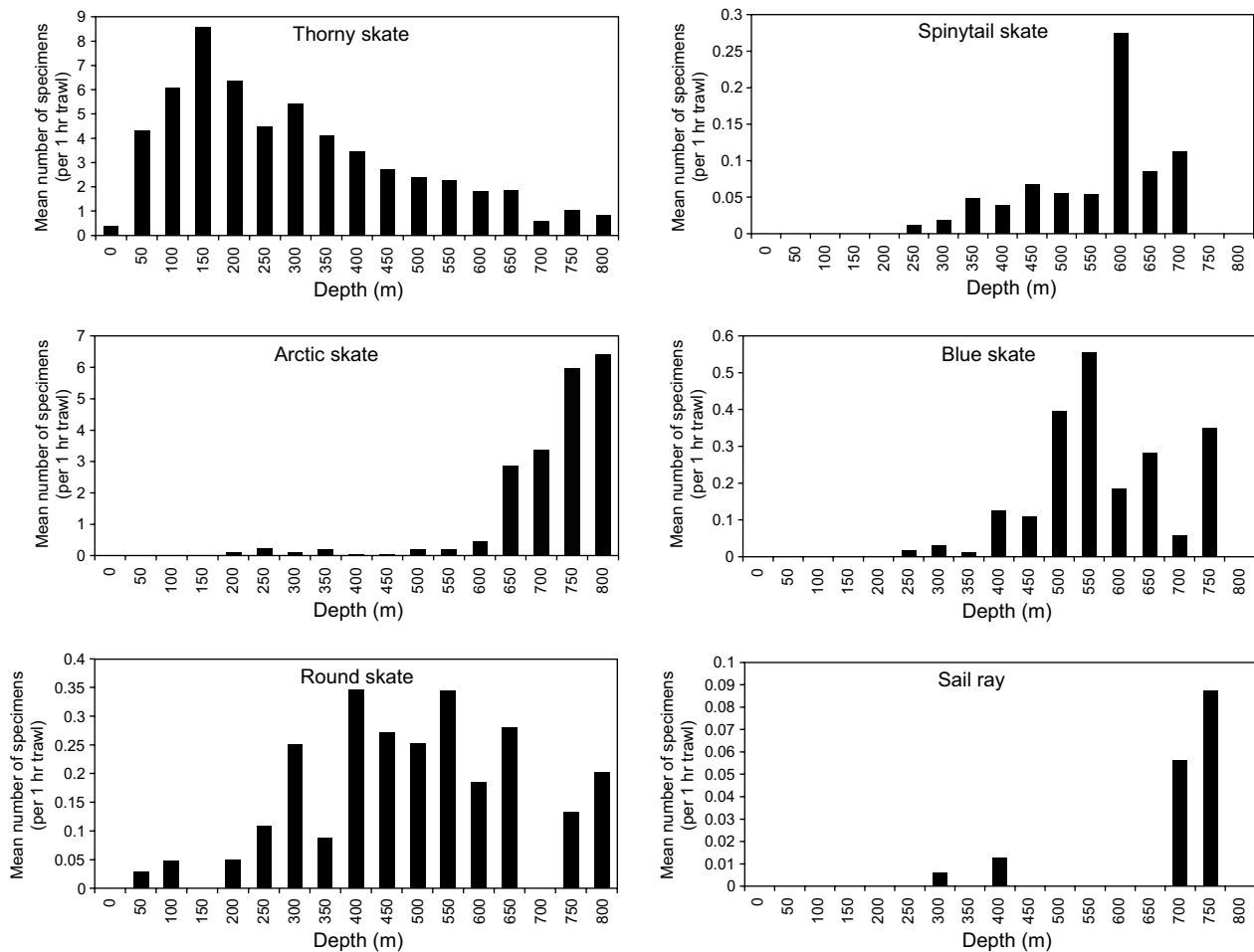


Fig. 2. Bathymetric conditions in the habitat of various skate species in the Barents Sea.

the coast of Norway and Murman to Bear Island (Fig. 6). Annual mean catches of the blue skate and spinytail skate were 0.1–0.2 and 0.01–0.1 fish per hour, and maximum catch rates were 2 and 3 fish per hour, respectively.

Size composition and sex ratio

Thorny skate ranged in size from 10 to 71 cm (Fig. 7) and the mean length of males and females over the four survey years ranged from 36.4 to 37.6 cm and 36.3 to 38.5 cm, respectively. Females were slightly more abundant than males, and the sex ratio changed from 1:1.2 in 1998 to 1:1 in 2001. Changes in the abundance of different size groups were also noted, with an almost complete absence of fish in some size groups, and an overwhelming prevalence of one sex in some size groups.

The size range of round skate was 11–56 cm (Fig. 8), and mean length of both males and females tended to decrease between 1998 and 2001, although sample sizes

were limited. Males and females were equally represented in catches, except in 2001 when the sex ratio was 1:0.7.

The size range of Arctic skate was 20–86 cm in males and 26–91 cm in females (Fig. 9). No clear trend in mean length was noted. Sex ratio varied considerably between years, from a slight prevalence of females in 1999 (1:1.2) to a predominance of males in 2001 (1:0.2).

Very few blue skate and spinytail skate were measured, and it was not possible to identify trends in their size or sex composition (Fig. 10). The length ranges of blue and spinytail skate were 30–160 cm and 28–182 cm, respectively. The length range of the 5 sail ray caught was 18–94 cm.

There were no significant differences between size distributions either by sex or from year to year for any skate species (Mann-Whitney U test, $P > 0.05$).

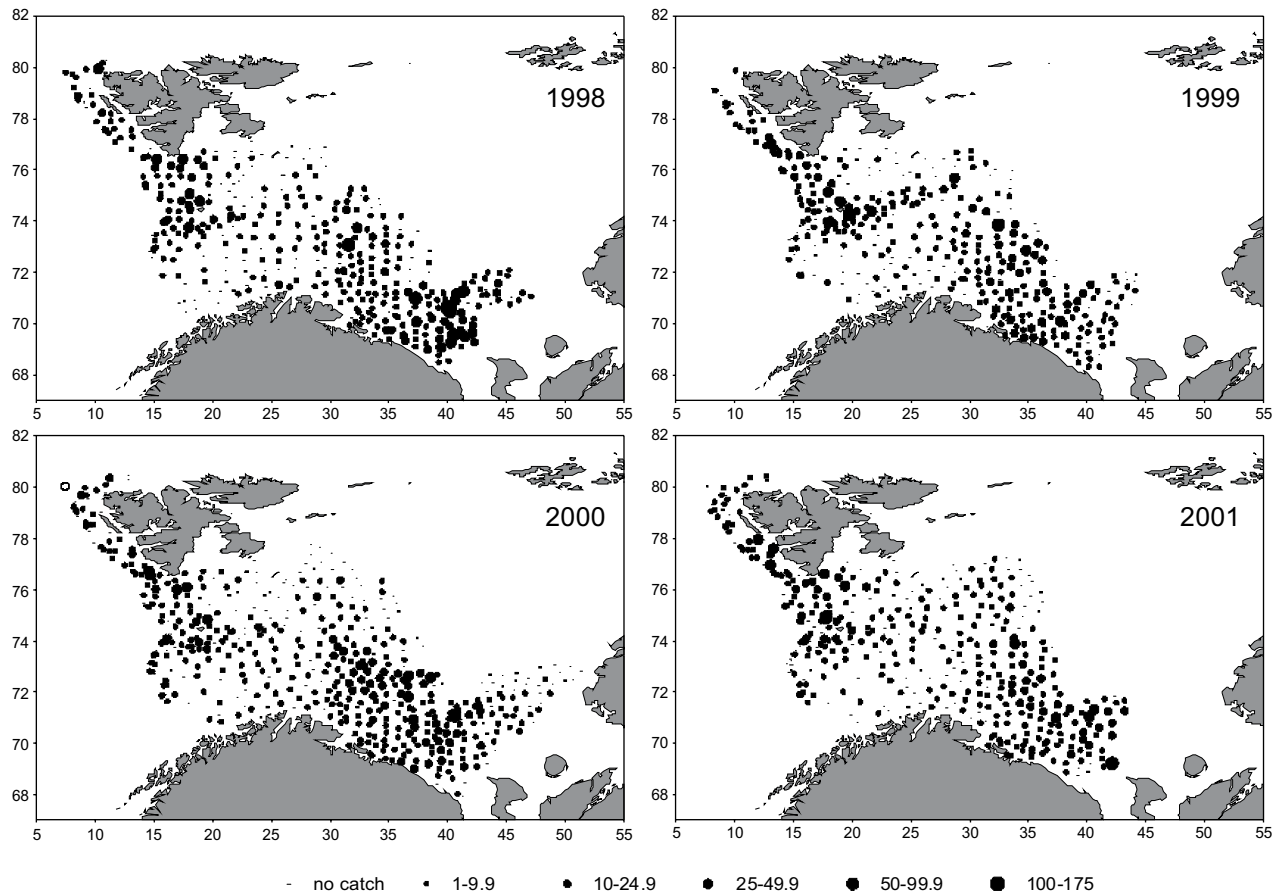


Fig. 3. Distribution of thorny skate according to trawl surveys during 1998–2001, specimen per 1 hour trawling.

Abundance and biomass

Estimated abundance of thorny skate over the period 1998–2001 varied from 130×10^6 fish in 1999 to 167×10^6 fish in 1998, and averaged 143×10^6 fish and estimated biomass varied between 88 000 and 106 000 tons (average 95 500 tons) (Table 2). A decline in the abundance and biomass of thorny skate <45 cm was noted in 1998–99, while the abundance and biomass of individuals >45 cm remained unchanged or increased slightly (Fig. 11).

The most abundant of the other skate species were Arctic and round skate, with an average abundance of 2.6×10^6 fish each, and an average biomass of 3 500 tons and 1 400 tons, respectively (Table 2). The abundance of blue and spinytail skate was lower (0.7×10^6 and 0.5×10^6 fish respectively), though the biomass of blue skate was estimated at 3 100 tons due to the large size of the

fish, while the biomass of spinytail skate did not exceed 600 tons.

Discussion

The distribution of various skate species in the Barents Sea appears to be related to water temperature. Thorny skates were found in the widest temperature and salinity ranges and occurred in all areas of the Barents Sea, including the most northern areas between Spitsbergen and Franz Josef Land (Smirnov *et al.*, 2000). Arctic skate is a cold water species, and in this study they occurred in the northern and deep-water areas of the Barents Sea. The distribution of other species (round, blue and spinytail skates, and sail ray) was limited to the areas of distribution of Atlantic water, occurring mainly in the southwestern part of the Barents Sea. The preferred depths and temperatures of these species in the Barents Sea correspond

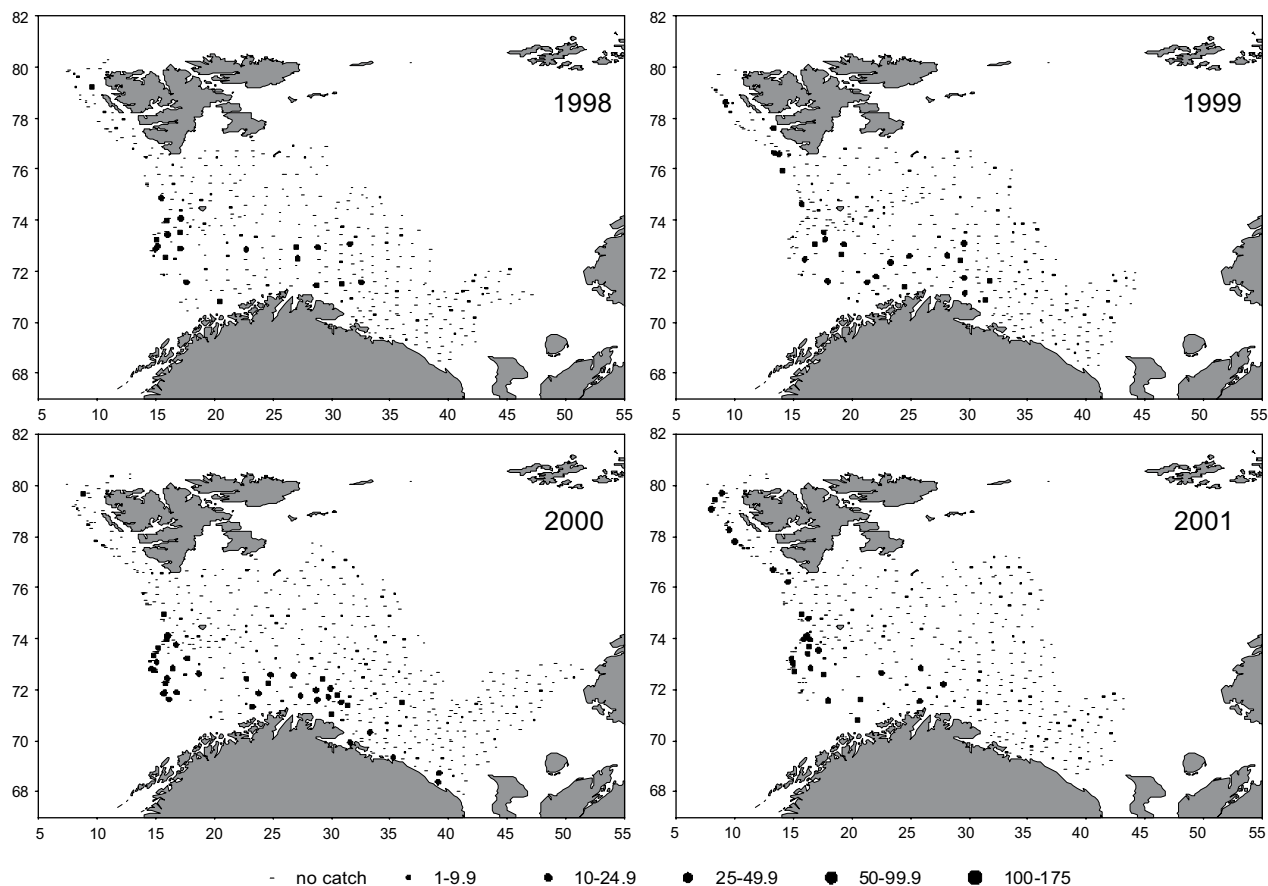


Fig. 4. Distribution of round skate according to trawl surveys during 1998–2001, specimen per 1 hour trawling.

well with the data of Skjaeraasen and Bergstad (2001) for the southern distribution area of skates on the slope of the eastern Norwegian Sea. However, it should be noted that the northern border of some species' distributions in the Barents Sea is much further north than previously described in the literature.

The observed maximum length of Arctic and blue skates was higher than the maximum length given by Stehmann and Bürkel (1984). The size distribution of Arctic skate was practically identical in the Barents Sea and in southern areas (Norwegian Deep and northeastern Norwegian Sea; based on Skjaeraasen and Bergstad, 2000, 2001), with two peaks (36–40 cm and >60 cm). The size distribution and dominant size groups of thorny and round skate in these areas were also similar, but the proportion of specimens <25–30 cm was much lower in the Barents Sea. This could be explained by the low fishing efficiency of research trawls for these size groups. Data on the size

and sex composition of skates, and of thorny skate in particular, may be indicative of some changes in their populations associated with exploitation. The observed reduced mean lengths changes in sex ratio and decreased number of smaller fish could have been caused by the selective impact of the fisheries on larger individuals and low production of these species, as noted in many cases for other areas where the pressure of fisheries on skate stocks has been high (Walker and Heessen, 1996; Walker and Hislop, 1998).

The species composition of skates caught in the Barents Sea differs from those recorded in the Norwegian Deeps and north-eastern Norwegian Sea (Skjaeraasen and Bergstad, 2000, 2001). While thorny skate is the dominant species in both areas, the portion of warm-water species (spinytail skate, sail ray) is lower and the portion of cold-water species (Arctic skate) is higher in the Barents Sea.

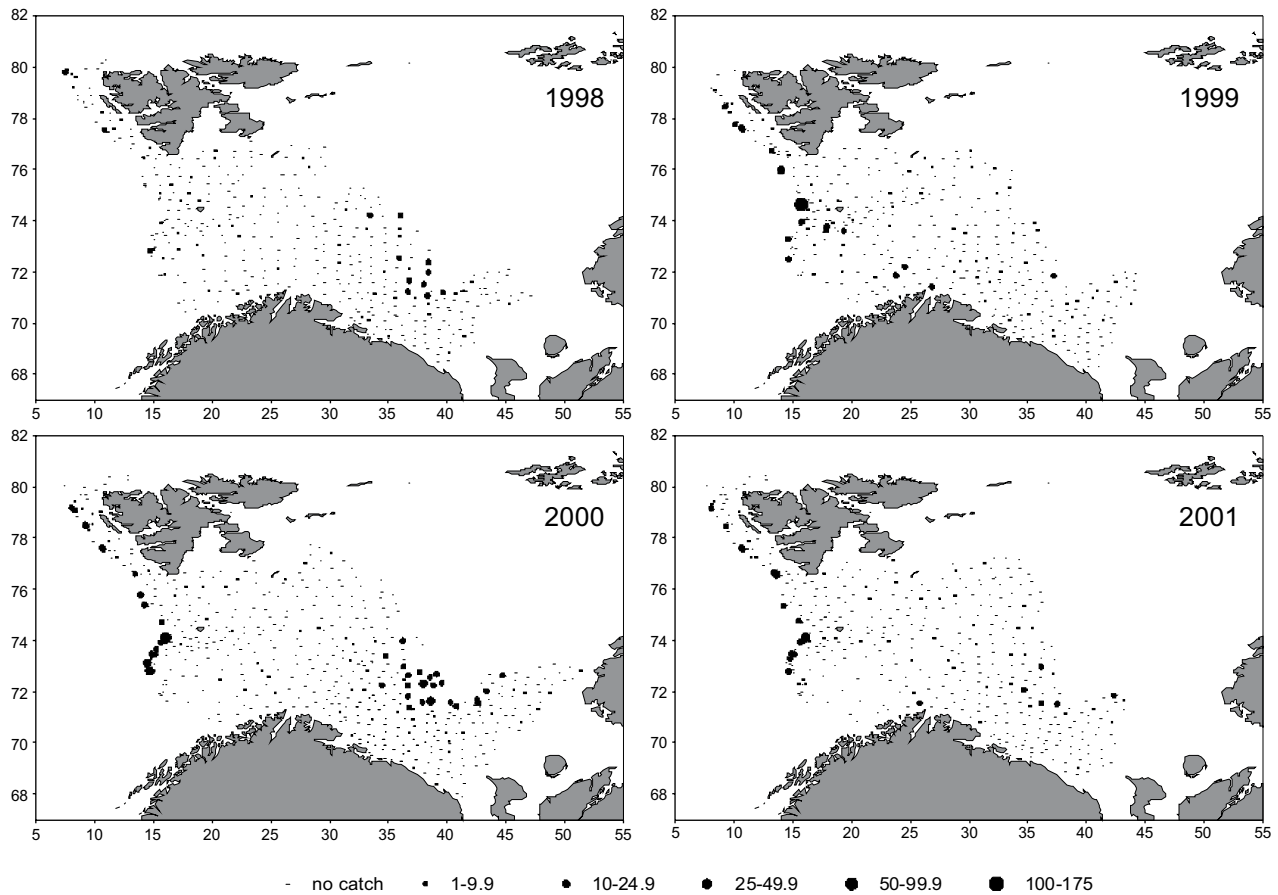


Fig. 5. Distribution of arctic skate according to trawl surveys during 1998–2001, specimen per 1 hour trawling.

Estimates of relative abundance and biomass for thorny skate and round skate remained almost unchanged over 1998–2001, which may suggest that their distribution area was well covered by the surveys and that these stocks are stable. Biomass estimates for thorny skate in 1990–96 (Dolgov, MS 1997) varied from 34 000 to 116 000 tons, compared to a mean of 95 500 tons in 1998–2001, although the area covered by surveys in the earlier surveys varied from year to year. Estimates of stock size for other species of skate appeared to be less realistic and could not be used for comparison of abundance and biomass trends. The survey did not cover the whole distribution of Arctic skate, which is also found between Spitsbergen and Franz Josef Land (Smirnov *et al.*, 2000). Few round and spinytail

skate were caught in the surveys. While the three species, thorny, Arctic and round skates, spawn in the Barents Sea (Berestovsky, 1994; our field observations), the scarcity of small-sized juvenile blue and spinytail skate and sail ray and the absence of mature specimens of these species suggests that their main spawning areas are outside the Barents Sea, and that their stocks there must be sustained through emigration of fish from more southern areas.

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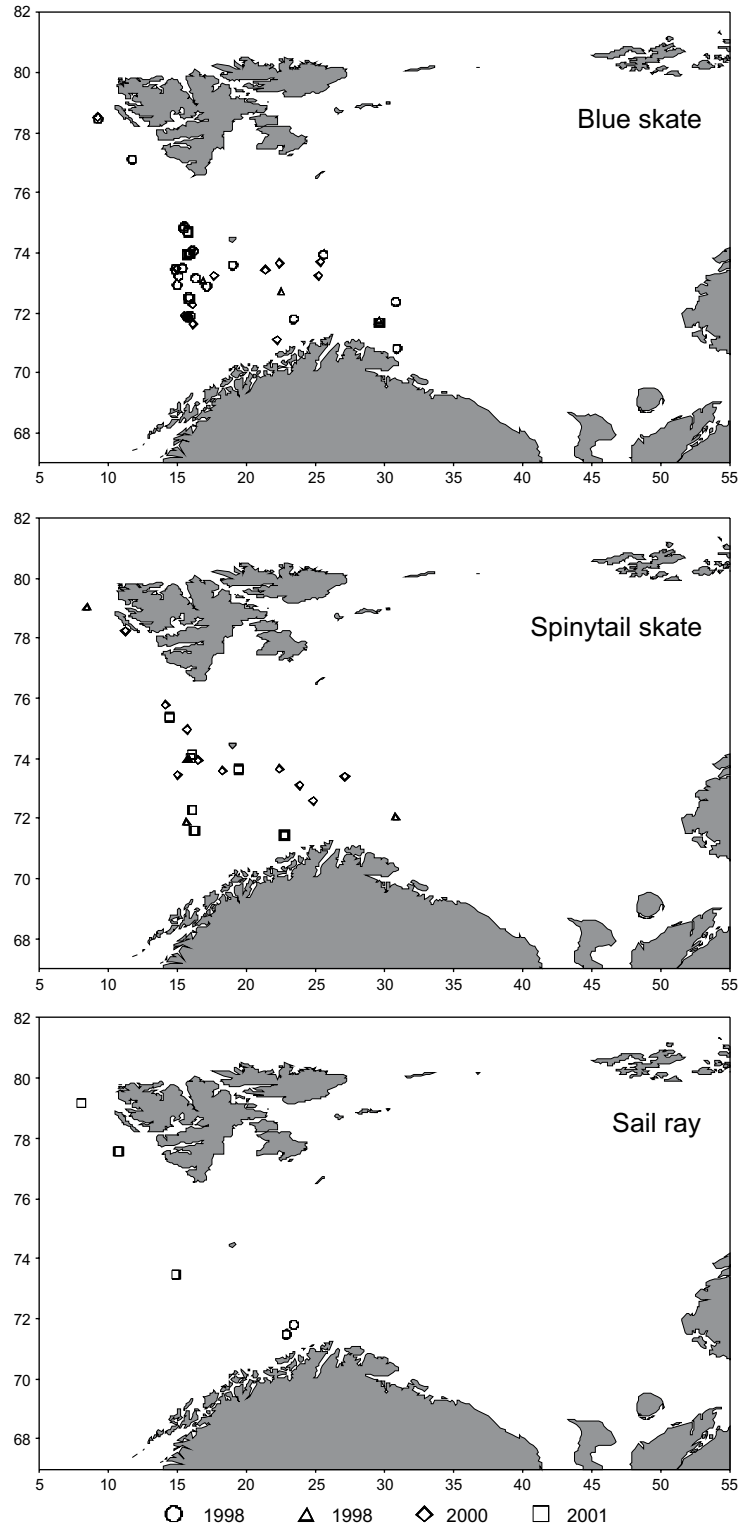


Fig. 6. Capture sites blue skate, spinytail skate and sail ray during 1998–2001.

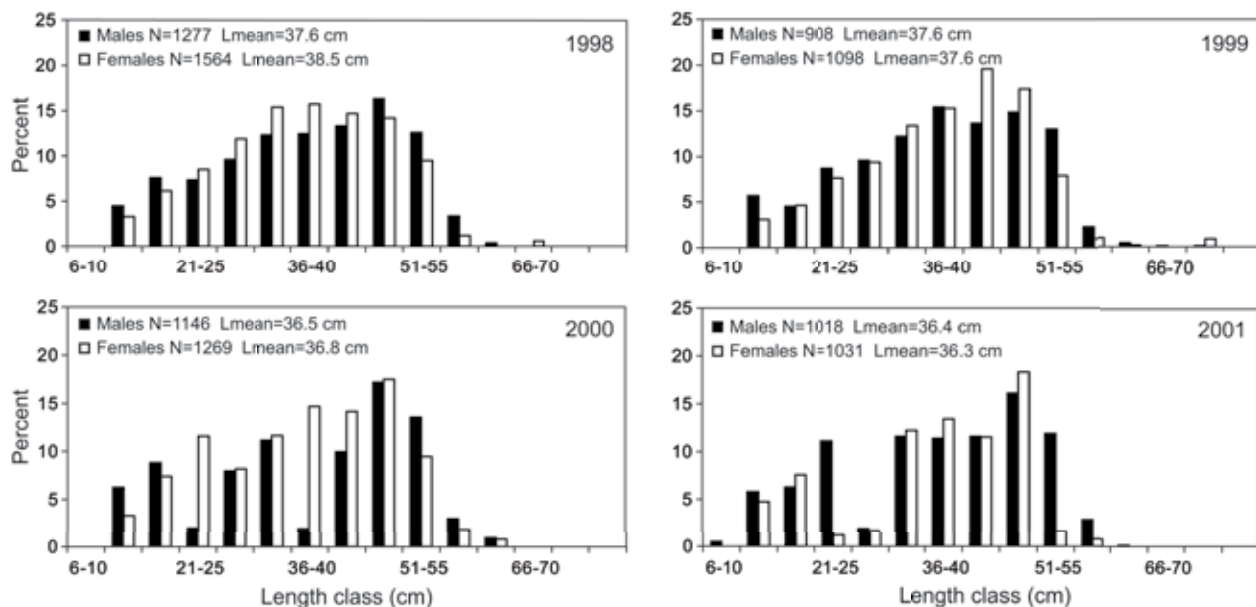


Fig. 7. Size distribution of thorny skate during 1998–2001.

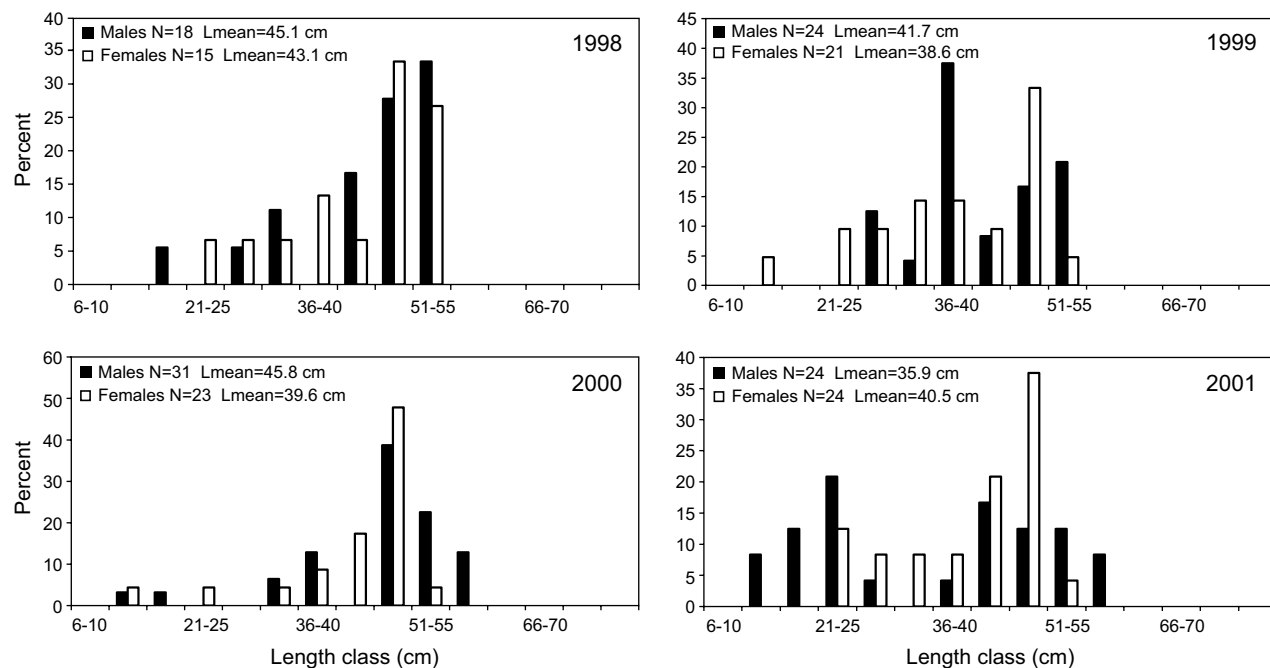


Fig. 8. Size distribution of round skate during 1998–2001

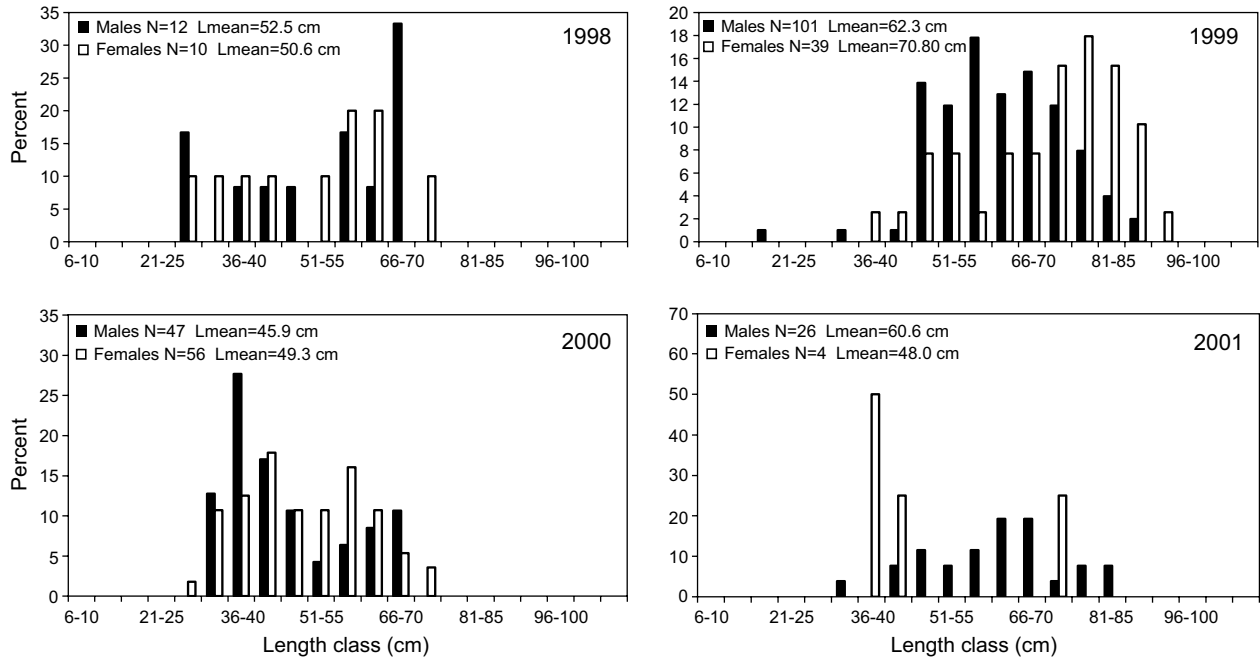


Fig. 9. Size distribution of arctic skate during 1998–2001.

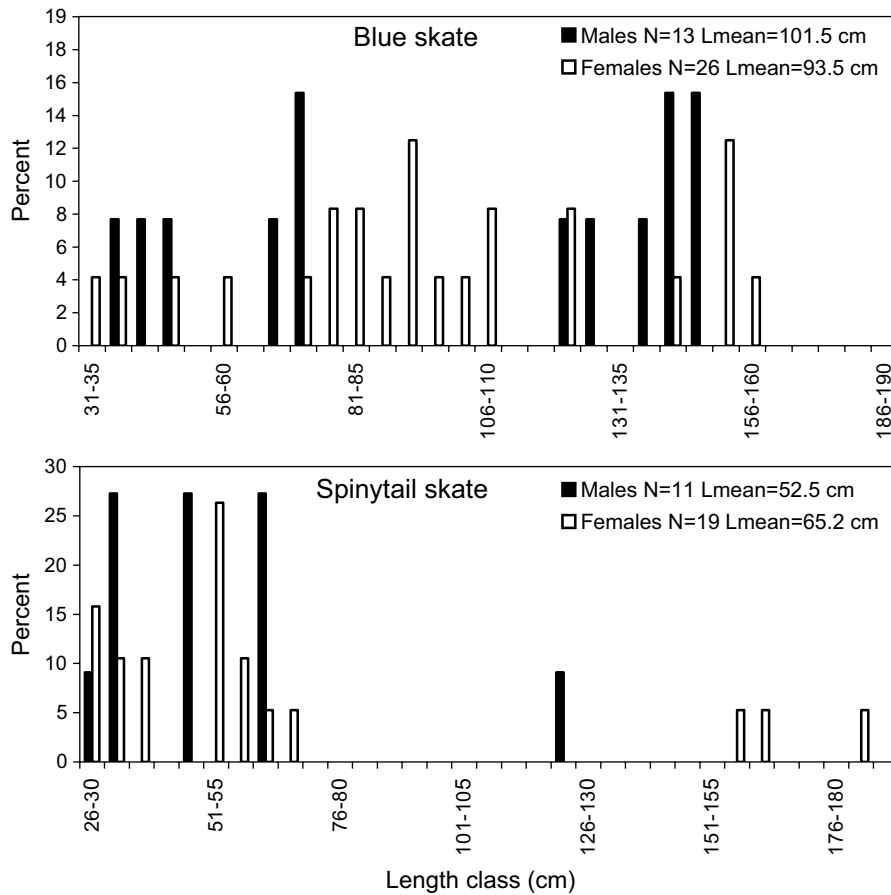


Fig. 10. Size distribution of blue and spinytail skates during 1998–2001.

TABLE 2. Estimated abundance ($\times 10^6$ fish) and biomass ($\times 10^3$ tons) of five skate species in the Barents Sea during 1998–2001.

Species		Year				Average
		1998	1999	2000	2001	
Thorny skate	Abundance	167.00	130.57	135.62	140.32	143.4
	Biomass	106.32	88.68	91.56	95.42	95.5
Round skate	Abundance	2.50	0.33	4.18	3.21	2.6
	Biomass	1.34	1.26	1.89	1.22	1.4
Arctic skate	Abundance	1.86	0.78	6.18	1.46	2.6
	Biomass	2.73	1.35	7.42	2.32	3.5
Blue skate	Abundance	1.41	0.30	0.75	0.27	0.7
	Biomass	1.25	3.99	1.88	5.17	3.1
Spinytail skate	Abundance	–	0.05	1.06	0.51	0.5
	Biomass	–	0.01	1.44	0.41	0.6
All skates	Abundance	172.78	132.03	147.79	145.76	149.72

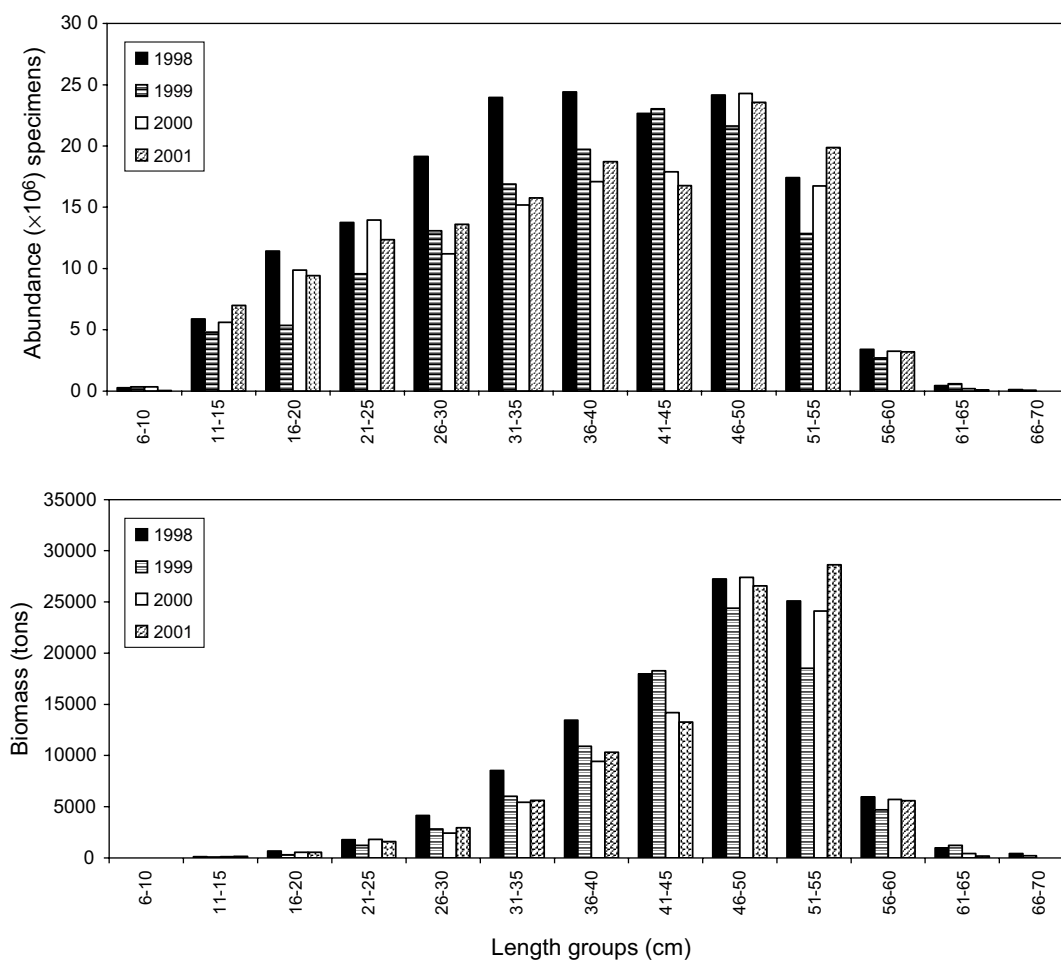


Fig. 11. Dynamics of abundance and biomass of thorny skate by size groups.

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