Acoustic researches of spatial distribution and abundance of arctic cod in the southwestern part of the Chukchi Sea in 2003–2020

Mikhail Kuznetsov, Vladimir Polyanichko, Eugeny Syrovatkin

Pacific branch (TINRO) of the "Russian Federal Research Institute of Fisheries and oceanography" (VNIRO)

E-mail: mikhail.kuznetsov@tinro-center.ru

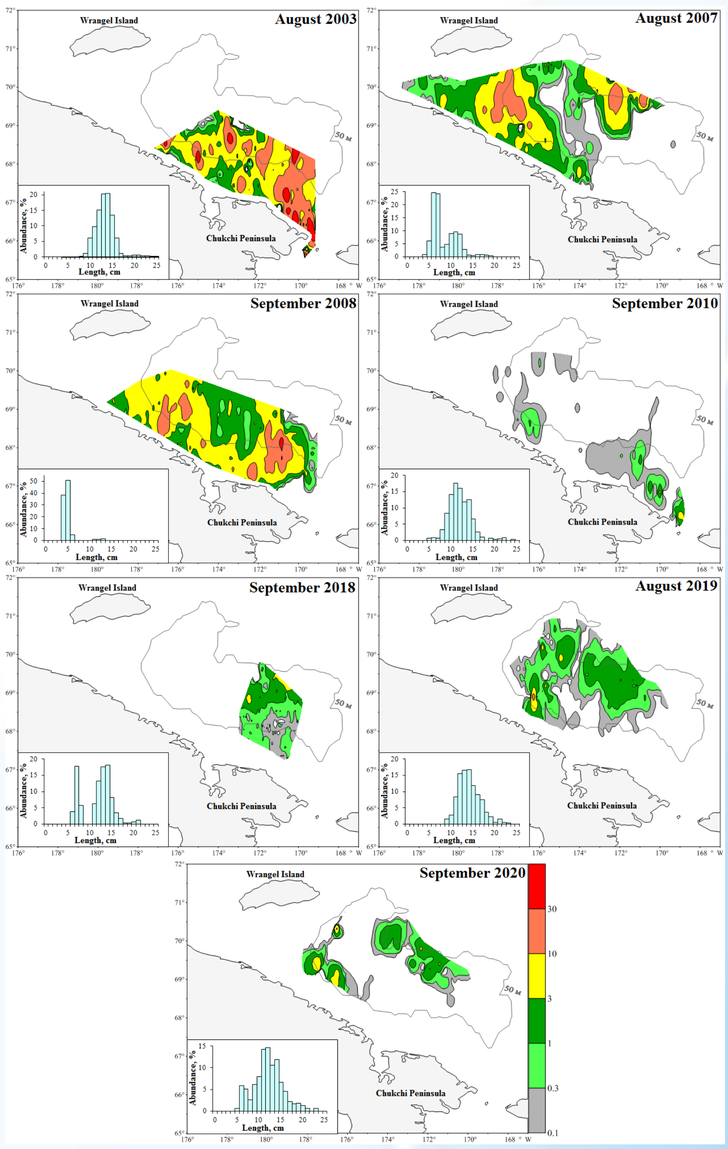

Fig. 1. Spatial distribution of arctic cod (×10⁶ ind./nmi²) in the southwestern Chukchi Sea by results of acoustic surveys in 2003–2020 (Insert: size composition of arctic cod in trawl catches)

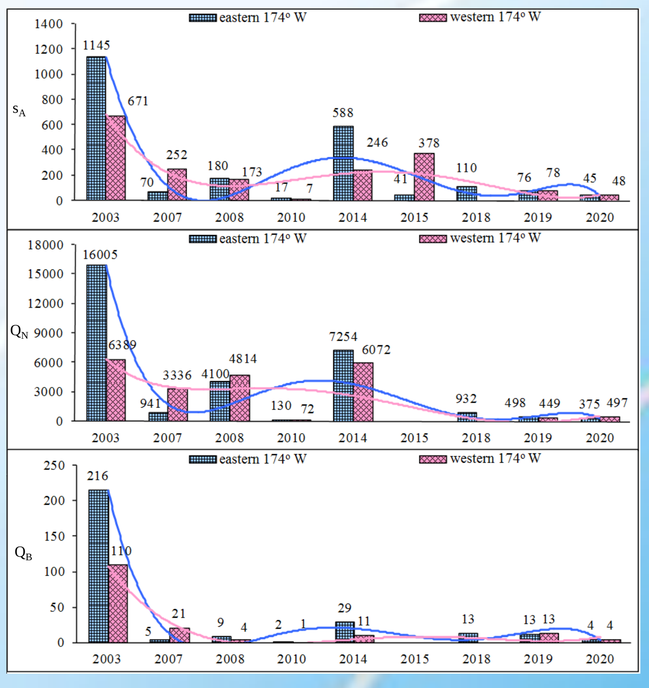

Fig. 2. Interannual dynamics of the arctic cod aggregations density in the southwestern Chukchi Sea in the units of nautical area scattering coefficient (NASC) s_A (m²/nmi²), abundance Q_N (×10³ ind./nmi²) and biomass Q_B (×10³ kg./nmi²)

Year	Area									
	to the east of 174° W					to the west of 174° W				
	A	s_A	Q_n	Q_b	L_{av}	A	s_A	Q_n	Q_b	L_{av}
	nmi²	m²/nmi²	×10³ ind./nmi²	×10³ kg./nmi²	cm	nmi²	m²/nmi²	×10³ ind./nmi²	×10³ kg./nmi²	cm
2003	16494	1145	16005	216	12.5	6611	671	6389	110	12.4
2007	22600	70	941	5	7.8	17810	252	3336	21	8.6
2008	19082	180	4100	9	5.6	13894	173	4814	4	4.7
2010	20914	17	130	2	12.9	15964	7	72	1	10.3
2014	1952	588	7254	29	7.3	1519	246	6072	11	5.4
2015	402	41 (93)	-	-	-	835	378 (207)	-	-	-
2018	10562	110	932	13	10.8	-	-	-	-	-
2019	17620	76	498	13	13.3	11903	78	449	13	13.1
2020	16931	45	375	4	11.2	12563	48	497	4	11.0

Fig. 3. Estimates of arctic cod abundance in the southwestern Chukchi Sea in August–September 2003–2020: A — survey area (nmi²); $L_{av.}$ — weighted average length of fish (cm)

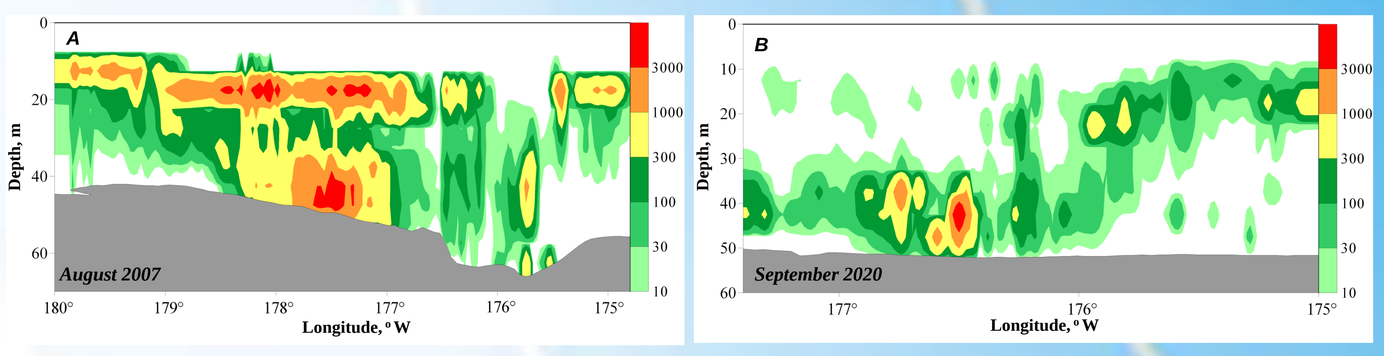

Fig. 4. Vertical distribution of arctic cod abundance, by strata (×10³ ind./ nmi² per 5 m stratum) along the transects in the southwestern Chukchi Sea

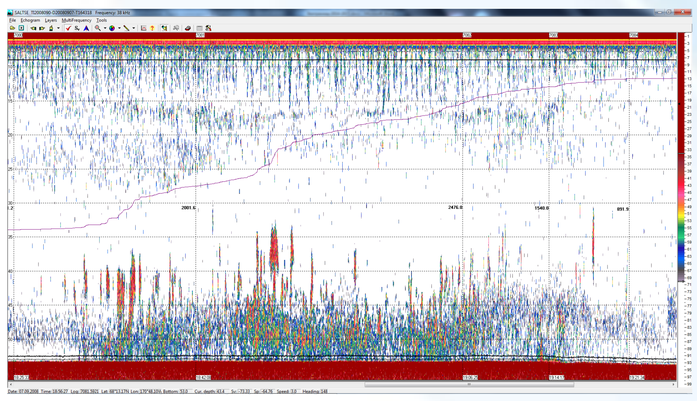

Fig. 5. Acoustic image of arctic cod aggregations obtained in the southwestern Chukchi Sea eastward from 174°W (September 2008)

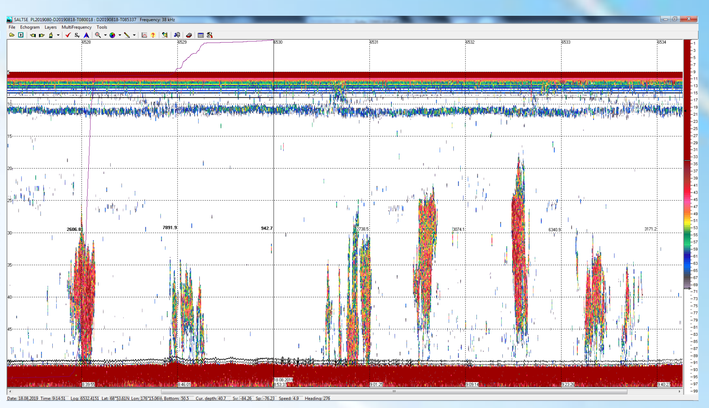

Fig. 6. Acoustic image of arctic cod aggregations in the southern part of the Chukchi Sea (August 2019)

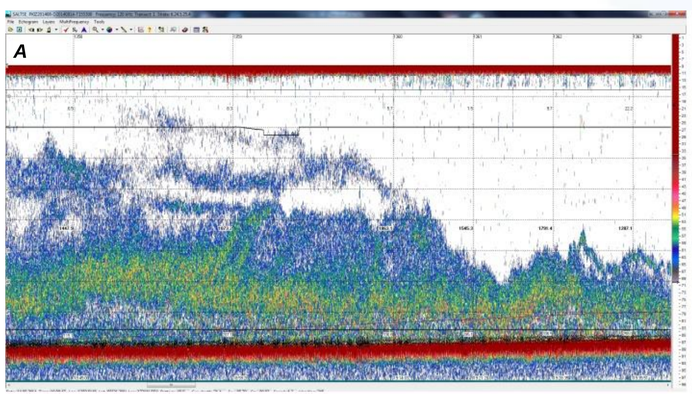

Fig. 7. Acoustic image of arctic cod aggregations obtained in the Chukchi Sea in September 2014: A – day, B – night

The features of spatial distribution (Fig.1) and abundance (Fig.2-3) of arctic cod (Boreogadus saida) were analyzed using the data sets from the acoustic-trawl surveys conducted by TINRO in southwestern part of the Chukchi Sea in August–September 2003-2020. The highest registered arctic cod abundance in the form of nautical area backscattering coefficient s_A (m²/nmi²), fish density by number (×10³ ind./nmi²) and biomass (×10³ kg./nmi²), were recorded in August 2003 (Fig.2-3). In 2007-2008, acoustic estimates of fish significantly decreased and in 2010 were at the lowest for the entire series of observations. In 2014, the abundance of arctic cod in the surveyed area noticeably increased due to the high proportion of juveniles in the aggregations. However, in 2015 arctic cod density again decreased and in 2018-2020 continued to decline, reaching the minimum values in 2020. At the same time, the influence on arctic cod distribution of warm Bering Sea current and the growth of walleye pollock abundance in this region became particularly noticeable.

The two–layer vertical structure of aggregations is indicative in the near–surface and near–bottom layers (Fig. 4). To the east of 174°W, aggregations are usually formed by larger individuals (Fig. 3) in the near-bottom layer (Fig. 5). In the western sector, they have a two-layer structure with a predominance of juveniles in the upper layer (Fig. 4A). There are also acoustic images of polar cod in the form of series of schools, the high density of which indicates their migratory behavior (Fig. 6).

The day/night dependence of arctic cod vertical movements was not registered. At night the structure of aggregations was usually more sparse. However, aggregations were also in the form of dense schools, both in the daytime and at night (Fig. 7).

During the observation period since 2003, there have been significant interannual fluctuations in the abundance of polar cod within the study area, with a general decrease in its stocks over the past 5 years. Sharp interannual fluctuations in the abundance of polar cod are typical of this short-cycle species. In addition, it should be taken into account that the water area of the Chukchi Sea, which has been surveyed for a number of years, is only a part of the polar cod's activity range. Part of the fish, possibly the vast majority, remained outside the research area.

The decrease in polar cod concentration in the southwestern part of the Chukchi Sea is taking place against the backdrop of a general warming in the Arctic and a reduction in ice cover. This situation, of course, affects the extent of the distribution of polar cod in a southerly direction. The decrease in polar cod abundance is apparently facilitated by the high temperature background, which has been created in the research area in recent years under the influence of Pacific water masses entering through the Bering Strait, and which is, at the same time, favorable for the penetration of Bering Sea pollock into this part of the Chukchi Sea.

PICES-2022 Annual Meeting Sept. 23 – Oct. 2, Busan, Korea