# SHRIMP IN ARNARFJÖRÐUR – *Pandalus borealis*

## THE FISHERY

Shrimp fishing started in Arnarfjörður in the 1930's. Between 1960 and 2015, the catch in Arnarfjörður fluctuated between 100 and 850 tonnes, except in the quota years 2005/2006 and 2006/2007 (Figure 1) when no fishing was allowed due to low shrimp biomass index in the area. Since 1994, the catch has decreased steadily and was only 116 tonnes in the quota year 2016/2017. No fishing was allowed in 2017/2018 due to a low shrimp biomass index. Since 2018, the catch ranged between 140 and 200 tonnes. Catch per unit effort (CPUE) was relatively stable between 1960 and 1985, with a sharp increase in the following decade. Since 2000, CPUE has increased steadily, mainly due to increased density of shrimp within the innermost part of the fjord.

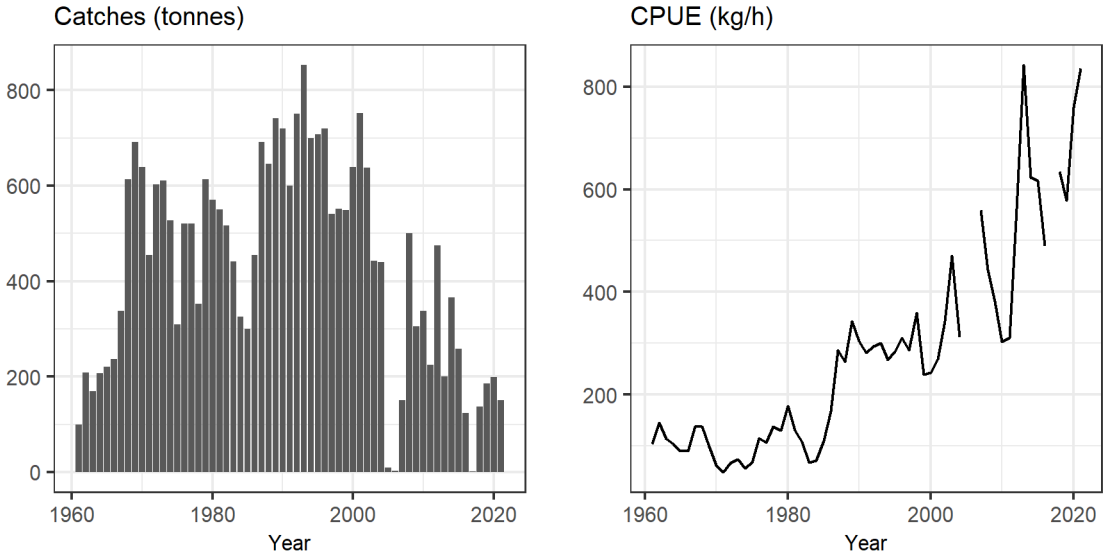


**Figure 1. Shrimp in Arnarfjörður. Total catch and catch per unit effort.**

The distribution of the fishery has varied over time (Figure 2). The main fishing area has decreased and since 2009 most of the catch has been taken from a relatively small area within the innermost part of Arnarfjörður.

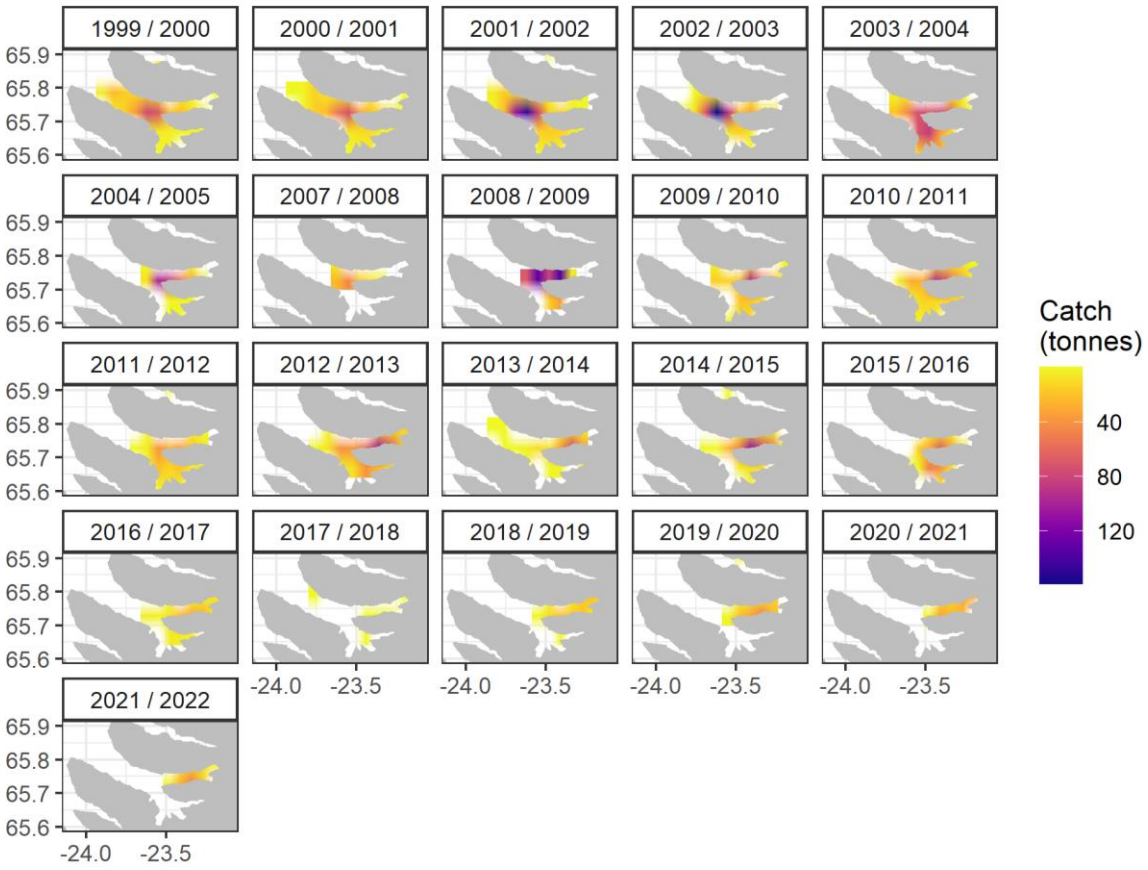


**Figure 2. Shrimp in Arnarfjörður. Distribution of shrimp catch.**

The shrimp fishery was conducted in October and November 2021 but was initiated again in April after four months break (Figure 3).

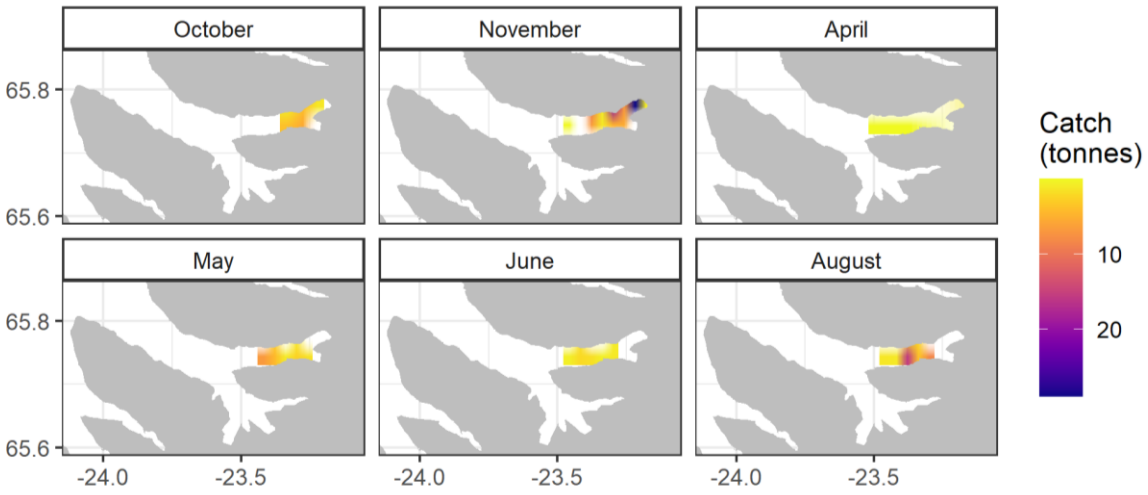


**Figure 3. Shrimp in Arnarfjörður. Distribution of shrimp catch by month in the quota year 2021/2022.**

## SURVEY DATA

The annual Icelandic shrimp survey has been conducted since 1988 in Arnarfjörður in the autumn. The 2022 survey was conducted on 22-23 September and 2-3 October and included 22 fixed stations at depths of 52-98 m. Information on sampling procedure can be found in the manual 'Handbók um stofnmælingu rækju 2022' (Jónsdóttir 2022).

In 1988–1996, shrimp was found throughout the whole fjord (Figure 4). In 1997, the distributional area decreased and since 2005 shrimp has only been found within a small area at the innermost part of the fjord. These changes in distribution are thought to be mainly due to increased abundance of cod and haddock in the outer part of the fjord. In 2022, northern shrimp was mainly found deep in Arnarfjörður (Borgarfjordur, the inner and northern fjord within Arnarfjordur).


**Figure 4. Shrimp in Arnarfjörður. Distribution and abundance of shrimp in the annual shrimp survey. X denotes stations where no northern shrimp was found.**

## INDICES

Four indices are used to assess the state of the stock; total biomass, fishable biomass, female biomass and juvenile biomass. Juveniles include all individuals equal to and below 13 mm carapace length while the fishable biomass index includes all individuals equal to and above 15.5 mm carapace length. Individuals between 13 and 15.5 mm carapace length are divided between the juvenile and fishable biomass indices. The female biomass includes all females.

The total stock and fishable indices were relatively stable until 2005 when they decreased sharply (Figure 5). Since 2006 the indices were again relatively stable but at a lower level compared with before. However, in 2016 the indices decreased, and the fishable index was slightly above the reference level where the state of the stock is considered critical. The fishable index value of 20% of the mean of the three highest indices ($I_{lim}$) is used as a proxy for $B_{lim}$. In 2017 the fishable index was at historically low levels and below the reference level. In 2018-2021, the fishable biomass index was just above the reference level and in 2022 it increased to levels seen in 2013-2015.

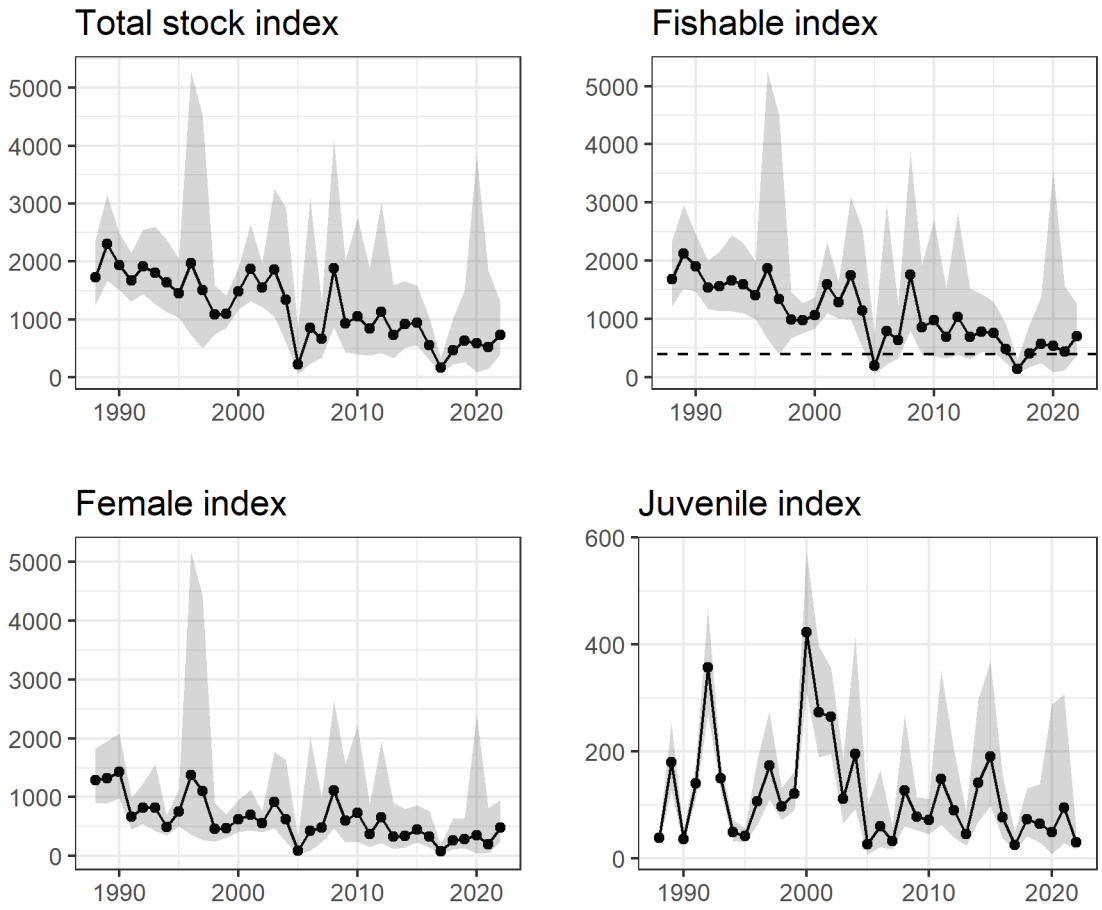


**Figure 5. Shrimp in Arnarfjörður. Stock biomass index, fishable biomass index, female biomass index and juvenile biomass index of shrimp. The horizontal line indicates a value where the state of the stock is considered to be critical (20% of the mean of the three highest indices).**

## LENGTH DISTRIBUTION

Since 2011, the mean length of females has been lower and female maximum length has not reached the same length as before and since 2016, the large individual females were not found in Arnarfjörður (Figure 6). In 2022, the number of males were below average.

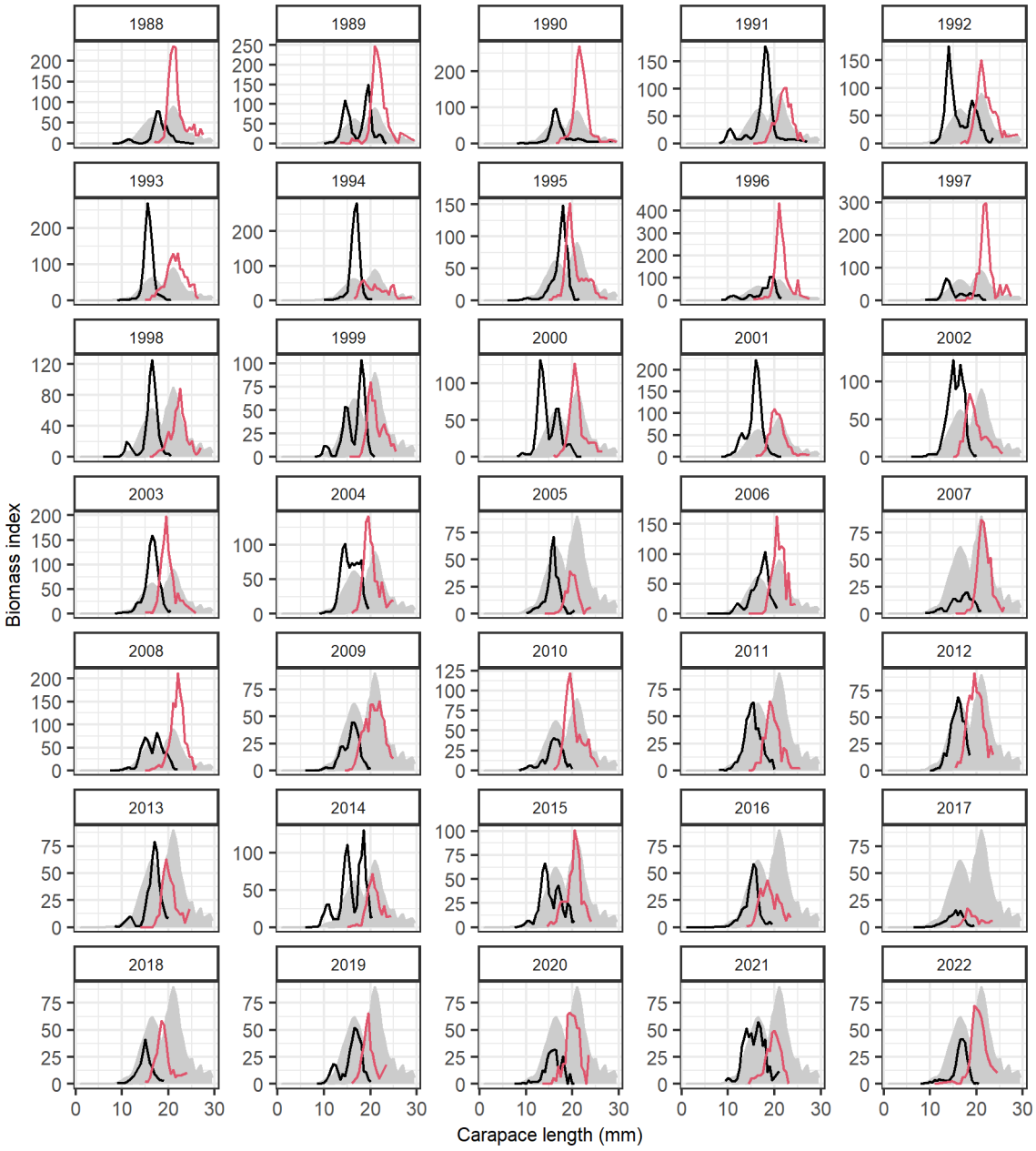


**Figure 6. Shrimp in Arnarfjörður. Length distribution. The black line indicates males, and the red line females. The grey area is the mean length distribution of both sexes for the whole study period. Note different scales on y-axes.**

## ABUNDANCE OF COD AND HADDOCK

The cod abundance index of 1 year and older has fluctuated without a trend throughout the study period (Figure 7). The haddock abundance index (1 year and older) increased from 1994 to 2008 but decreased to a low level in 2014 and has since then fluctuated with increasing trend (Figure 7). The number of haddock 1 year and older was though in 2020-2022 the highest values since 2011. In 2020-2021, the abundance of juvenile cod and haddock was low but haddock juvenile index increased in 2022.

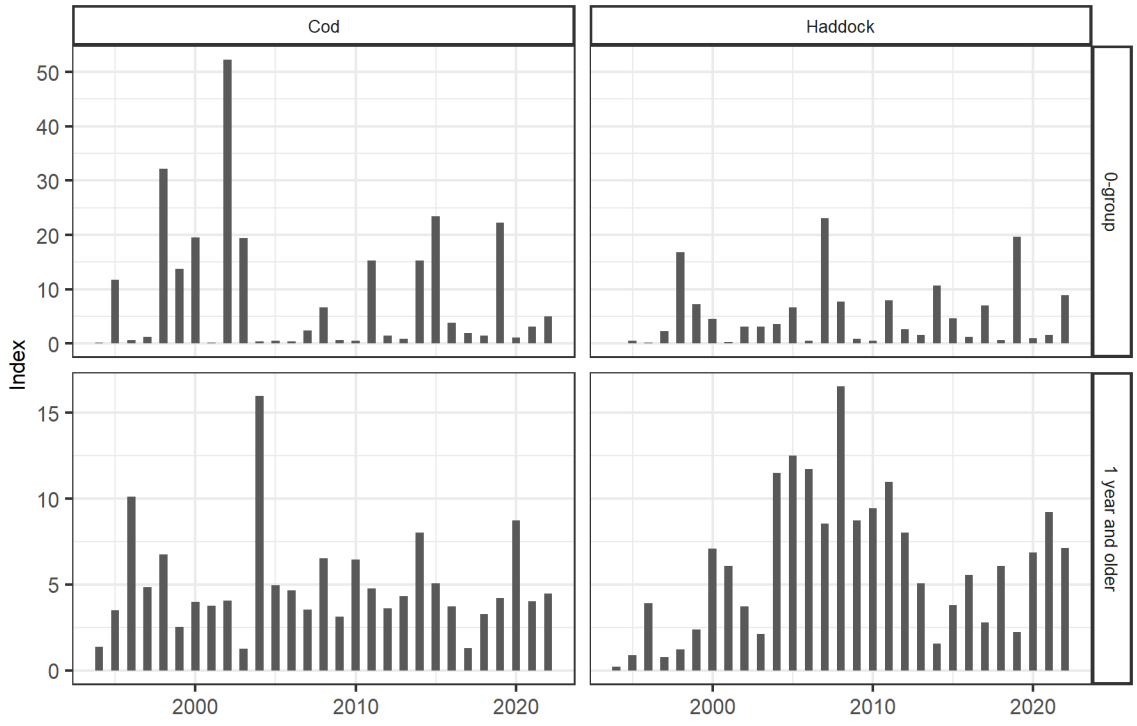


**Figure 7. Cod and haddock in Arnarfjörður. Abundance indices of cod and haddock in the annual shrimp survey.**

## MANAGEMENT

The Ministry of Food, Agriculture and Fisheries is responsible for management of all marine fisheries in Iceland and implementation of legislation. The fishing season was from early winter (following the annual Icelandic shrimp survey in September/October) until 30 April but in 2017 it was changed to 31 August.

**Table 1. Shrimp in Arnarfjörður. Fishable biomass index, state of the stock (relative to the mean of the three highest indices), advice, catch (tonnes in fishing year) and $F_{proxy}$.**

| Year | Biomass index | Relative state | Rec. TAC | National TAC | Catch | $F_{proxy}$ |
|---|---|---|---|---|---|---|
| ***1988/89*** | 1686 | 0.86 | | | | |
| ***1989/90*** | 2121 | 1.08 | | | | |
| ***1990/91*** | 1903 | 0.97 | 700 | 700 | 720 | 0.38 |
| ***1991/92*** | 1534 | 0.79 | 600 | 600 | 605 | 0.39 |
| ***1992/93*** | 1561 | 0.80 | 750 | 750 | 751 | 0.48 |
| ***1993/94*** | 1659 | 0.85 | 850 | 850 | 853 | 0.51 |
| ***1994/95*** | 1591 | 0.81 | 700 | 700 | 699 | 0.44 |
| ***1995/96*** | 1410 | 0.72 | 700 | 700 | 708 | 0.50 |
| ***1996/97*** | 1864 | 0.94 | 700 | 700 | 720 | 0.39 |
| ***1997/98*** | 1337 | 0.66 | 550 | 550 | 546 | 0.41 |
| ***1998/99*** | 989 | 0.50 | 550 | 550 | 551 | 0.56 |
| ***1999/00*** | 977 | 0.49 | 550 | 550 | 548 | 0.56 |
| ***2000/01*** | 1067 | 0.54 | 650 | 650 | 639 | 0.60 |
| ***2001/02*** | 1596 | 0.80 | 750 | 750 | 752 | 0.47 |
| ***2002/03*** | 1285 | 0.66 | 650 | 650 | 637 | 0.50 |
| ***2003/04*** | 1744 | 0.89 | 750 | 750 | 748 | 0.43 |
| ***2004/05*** | 1145 | 0.59 | 450 | 450 | 440 | 0.38 |
| ***2005/06*** | 195 | 0.10 | 0 | 0 | 9 | - |
| ***2006/07*** | 794 | 0.41 | 0 | 0 | 3 | - |
| ***2007/08*** | 630 | 0.32 | 150 | 150 | 158 | 0.25 |
| ***2008/09*** | 1756 | 0.90 | 500 | 500 | 508 | 0.29 |
| ***2009/10*** | 856 | 0.44 | 300 | 300 | 314 | 0.37 |
| ***2010/11*** | 982 | 0.50 | 400 | 400 | 337 | 0.34 |
| ***2011/12*** | 695 | 0.36 | 200 | 200 | 224 | 0.32 |
| ***2012/13*** | 1037 | 0.53 | 450 | 450 | 475 | 0.46 |
| ***2013/14*** | 685 | 0.35 | 200 | 200 | 201 | 0.29 |
| ***2014/15*** | 777 | 0.40 | 350 | 350 | 366 | 0.47 |
| ***2015/16*** | 751 | 0.40 | 250 | 250 | 258 | 0.34 |
| ***2016/17*** | 483 | 0.25 | 167 | 167 | 124 | 0.26 |
| ***2017/18*** | 139 | 0.07 | 0 | 0 | 1 | - |
| ***2018/19*** | 399 | 0.20 | 139 | 139 | 137 | 0.34 |
| ***2019/20*** | 574 | 0.30 | 197 | 197 | 185 | 0.32 |
| ***2020/21*** | 535 | 0.27 | 184 | 184 | 199 | 0.37 |
| ***2021/22*** | 432 | 0.22 | 148 | 148 | 150 | 0.35 |
| ***2022/23*** | 698 | 0.36 | | | | |