ICELAND SCALLOP - HÖRPUDISKUR

Chlamys islandica

INTRODUCTION

Iceland scallop (*Chlamys islandica*) has been fished in several fjords and bays around Iceland since 1969, when the fisheries started in Ísafjarðardjúp with catch of 400 tonnes. In the following year, a fishery started in Breiðafjörður which has been the major fishing area ever since. From 1970 until the closure of the fisheries in 2003, a total of 254 thousand metric tonnes were landed from that area (Jónasson, 2007). Landings from other areas have been much lower with 18 and 14 thousand tonnes from Húnaflói and Ísafjarðardjúp, respectively. This report will focus only on the stock in Breiðafjörður, as no commercial fishing has taken place in other areas since 2002, apart from roughly 7 tonnes of diver-caught scallops in Ísafjarðardjúp during past three years (Figure 1).

The decline of the stock in Breiðafjörður in 1999-2003, which led to the closure of the fishery, is believed to be caused by several factors (Jonasson et al. 2007). The fishable stock consisted of few year classes and recruitment was scarce. High natural mortality caused by protozoan parasites (gray meat) was evident on all grounds, with annual mortality ratio as high as ~40% in the main fishing ground in the southern part of the fjord. The intensity of the mortality increased with scallop size and was most pronounced in the fishable part of the stock (>60 mm). Warmer waters and low levels of phytoplankton in addition to the disease caused general poor condition with smaller muscles and gonads. Total fishing mortality was also high and in combination with the above factors led to a collapse of the stock. During this period and earlier, there was a reduction in the distributional areas of the stock, especially the outer parts (Jónasson, 2007). In recent years infection levels have been low and muscle condition good.

COMMERCIAL FISHING

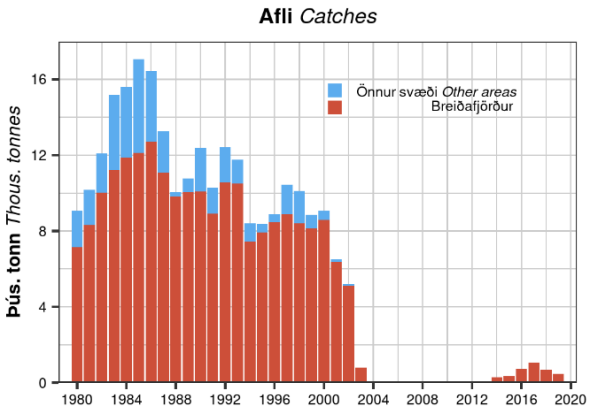

Figure 1. Iceland scallop. Total catch of Iceland scallop in Iceland and within Breiðafjörður.

Mynd 1. Hörpudiskur. Heildarafli hörpudisks og afli í Breiðafirði.

No fishery for Iceland scallop has been conducted in Breiðafjörður since 2003, except for an experimental fishery during the last six winters (2014-2019, Table 1). The experimental fishery is covered in next chapter.

At the start of the fisheries in the 1970s, the catch was between 2 000–4 000 tonnes but reached over 10 000 tonnes in 1982 (Figure 1). The catch was greatest in 1986 when 12 700 tonnes were fished. During 1996–2000, the average catch in Breiðafjörður was around 8 500 tonnes per year. The catch declined to 4 500 tonnes in the fishing year 2002/03, until the fishery was closed (Table 1).

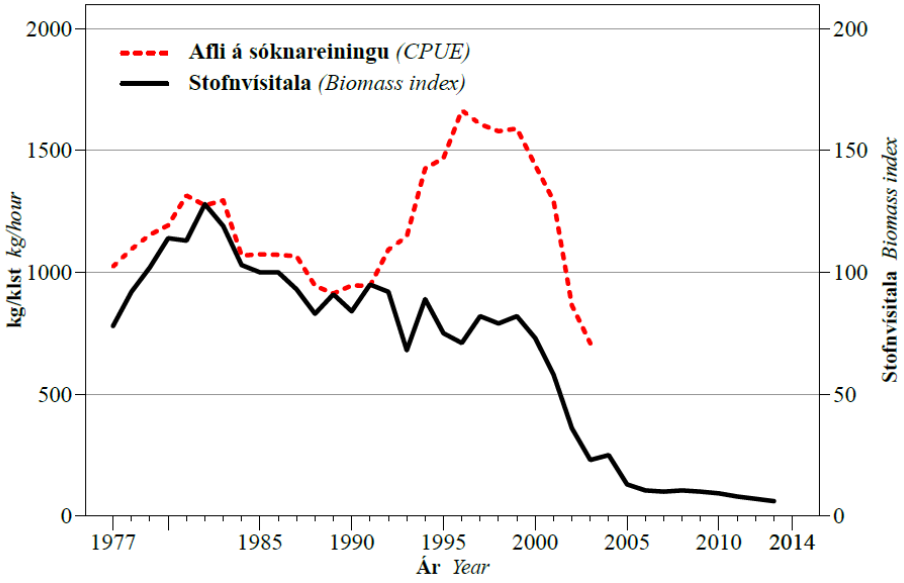

Figure 2. Iceland scallop. CPUE (kg/hour) and scallop biomass index from dredge survey in Breiðafjörður.

Mynd 2. Hörpudiskur. Afli á sóknareiningu (kg/klst) og lífmassavísitala hörpudisks (mæling með plóg) úr Breiðafirði.

Catch per unit effort (CPUE, standardized to one dredge) pooled for all areas in Breiðafjörður, was relatively stable, during 1986–1990, but increased considerably from 1991 to 1996 (Figure 2). During the years 1996–1998, it was high, but then declined sharply until 2003. The increase in CPUE in the early 1990s coincided with changes in the scallop fishing gear, when the fleet changed from sledge dredges to more efficient roller dredges (Jonasson, et al. 2007). The decline coincided with drop in the survey index.

EXPERIMENTAL FISHERY

In autumn 2014, an experimental fishery in Breiðasund in the southern part of Breiðafjörður yielded a catch of 281 tonnes. The experimental fishery was a joint program by the MFRI and local fishermen which supplied a boat for the camera survey that took place prior to the fishing activities in the following autumn/winter. The dredge used was lighter than the one that was used when the fishery was still open, but further modification and development of harvest technique is warranted. The aim of the program was to gather biological and fisheries data over a few years and propose optimal harvest ratio and management strategy for the stock. The autumn/winter of 2019 was the last year of the program.

Each year there were certain limits set for each region and the aim was to fish with different harvest ratios; 4%, 8% or 12%. Within each region the catch and effort were recorded on ~1.08 km^2 rectangles. The actual fishable area within each region was rather poorly known, but VMS data were gathered during the fishing activities. The original abundance estimate in each region will therefore be adjusted a posteriori. For definition of fishing grounds, a threshold was set at minimum 2 pings on towing speed at a resolution of 100*100 m. Areas smaller than 350.000 m^2 were excluded (fishable areas are larger than three 100*100 m squares).

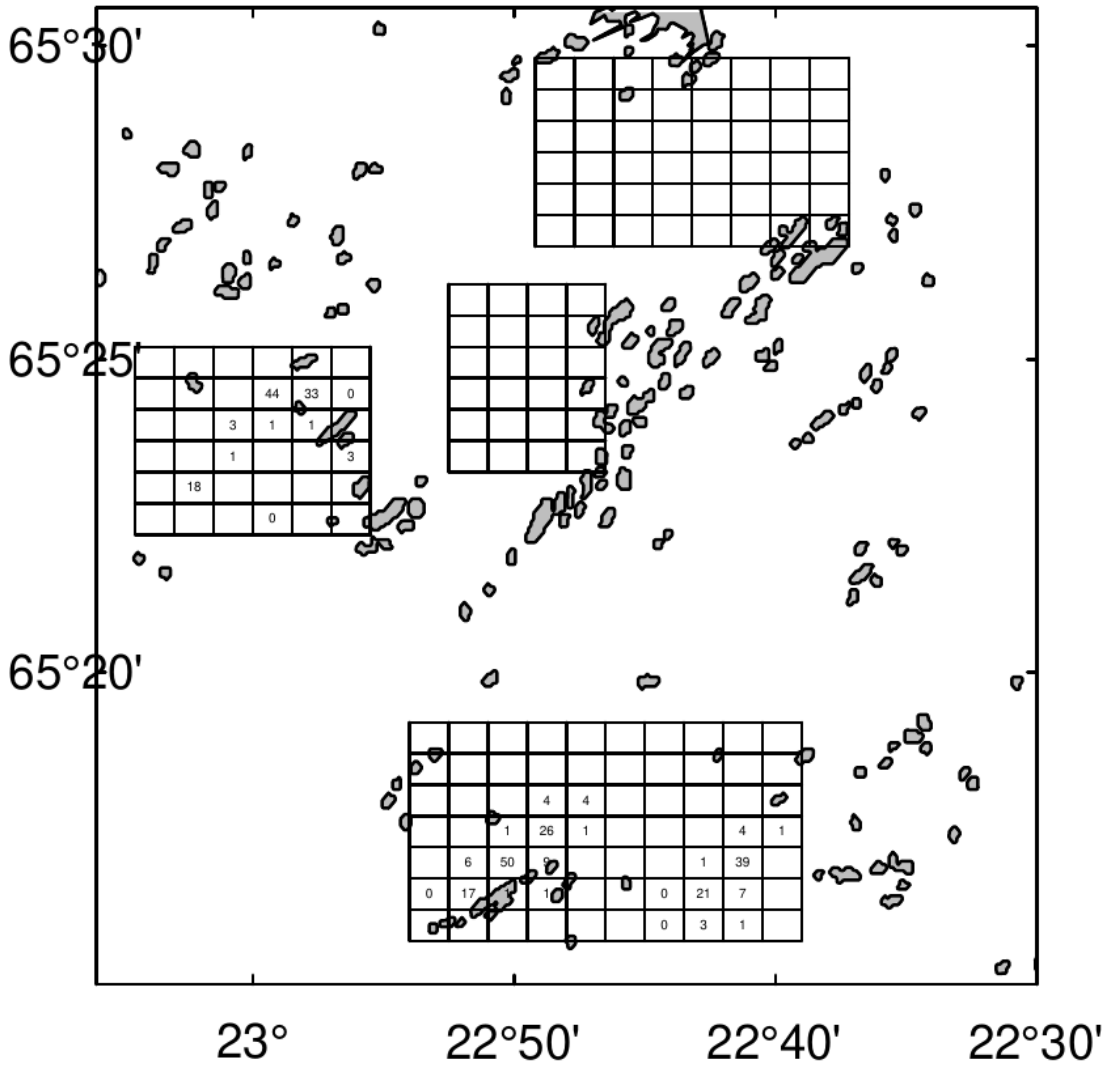

Figure 3. Iceland scallop. Catch (tonnes) in northern areas during autumn of 2019; west of Flatey region to the left, Látralönd region on the middle right, Skálmarnes region in the upper right, Bjarneyjar region in lower middle and Rúfeyjar region to the right of Bjarneyjar, within the same grid.

Mynd 3. Hörpudiskur. Yfirlit yfir afla (tonn) á norðursvæði haustið 2019. Svæði vestur af Flatey til vinstri, Látralandasvæði til hægri við miðju, Skálmarnessvæði til hægri að ofanverðu, Bjarneyjar að neðanverðu og Rúfeyjar hægra megin við Bjarneyjar innan sama hnitakerfis.

The experimental fishery continued during the winter 2015/2016, when 635 tonnes were caught on four defined fishing grounds outside of the traditional Iceland scallop grounds in Breiðafjörður. During the winter 2016/2107, 575 tonnes were caught on five different regions in the fjord. The original plan for the winter 2016/2017 was to harvest in total 950 tonnes on six regions with two boats (Table 2). In practice only one boat was active, and fishermen went on strike for 10 weeks (December–February).

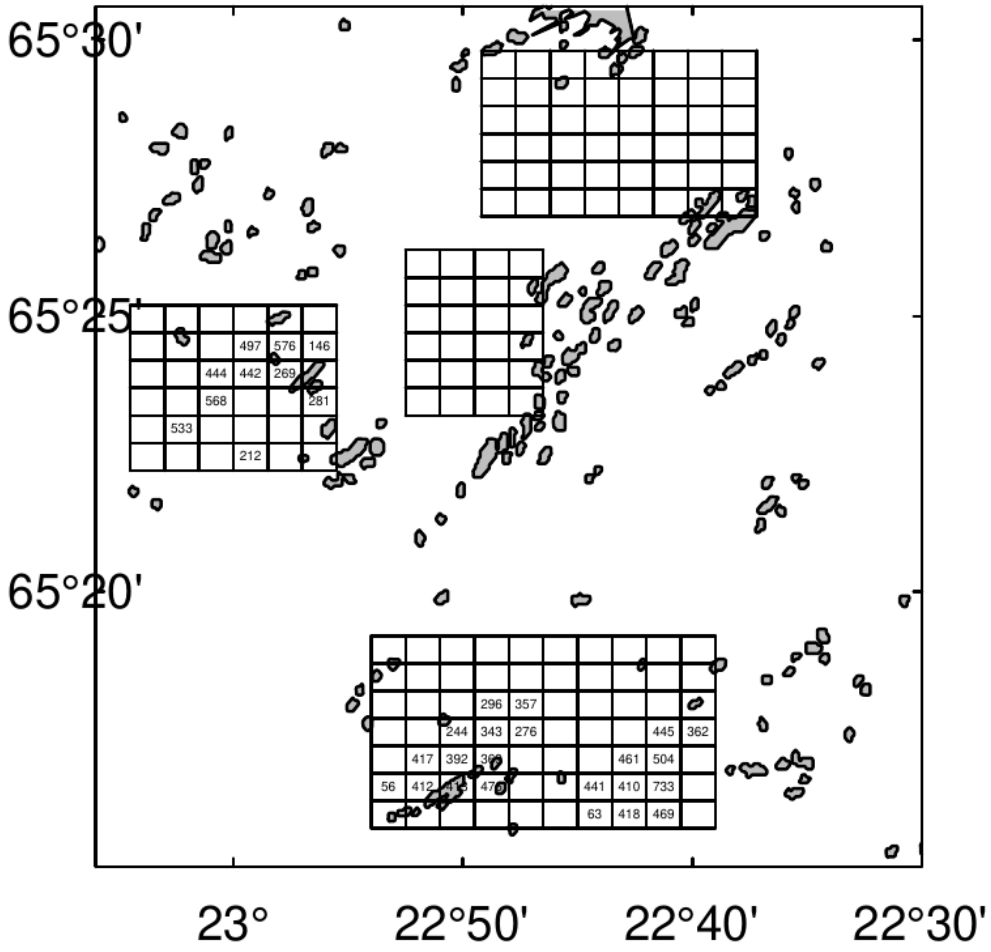

Figure 4. Iceland scallop. CPUE (kg per towed nautical mile) in northern areas during autumn of 2019, west of Flatey region on the left, Látralönd region on the middle right, Skálmarnes region on the upper right, Bjarneyjar region in lower middle and Rúfeyjar region to the right of Bjarneyjar, within the same grid.

Mynd 4. Hörpudiskur. Yfirlit yfir afla á sóknareiningu (kg á togmílu) á norðursvæði haustið 2019. Svæði vestur af Flatey til vinstri, , Látralandasvæði til hægri við miðju, Skálmarnessvæði til hægri að ofanverðu, Bjarneyjar að neðanverðu og Rúfeyjar hægra megin við Bjarneyjar innan sama hnitakerfis.

For the winter 2017/2018 it was proposed to fish 1030 tonnes on six areas within the fjord. Two boats participated in the fishery which lasted from September–December and 945 tonnes were landed. During the winter 2018/2019 it was proposed to fish 959 tonnes on seven areas with two boats. The fishing occurred in September-December and in total 694 tonnes were landed. Fishing was according to plan in the southern

region, and in Bjarneyjar and Rúfeyjar. In Flatey 205 tonnes of proposed 296 tonnes were fished and just few tonnes were landed from the northerly Látralönd and Skálmarnes areas.

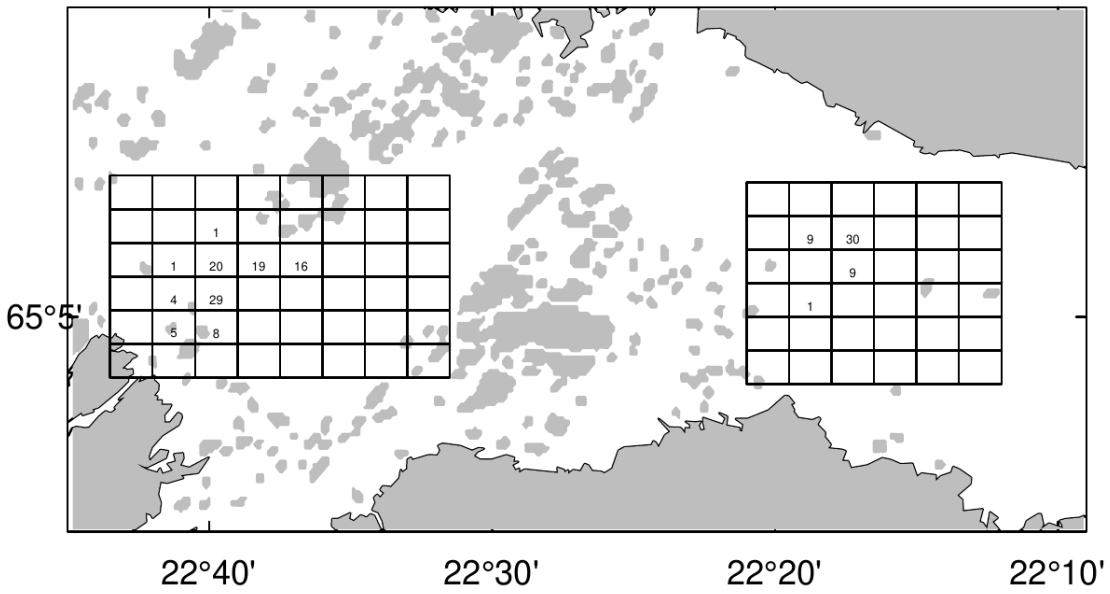

Figure 5. Iceland scallop. Catch (tonnes) in southern areas during autumn of 2019, Breiðasund region on the left and Hvammsfjörður region to the right.

Mynd 5. Hörpudiskur. Yfirlit yfir afla (tonn) á suðursvæði haustið 2019. Breiðasund til vinstri og Hvammsfjörður til hægri.

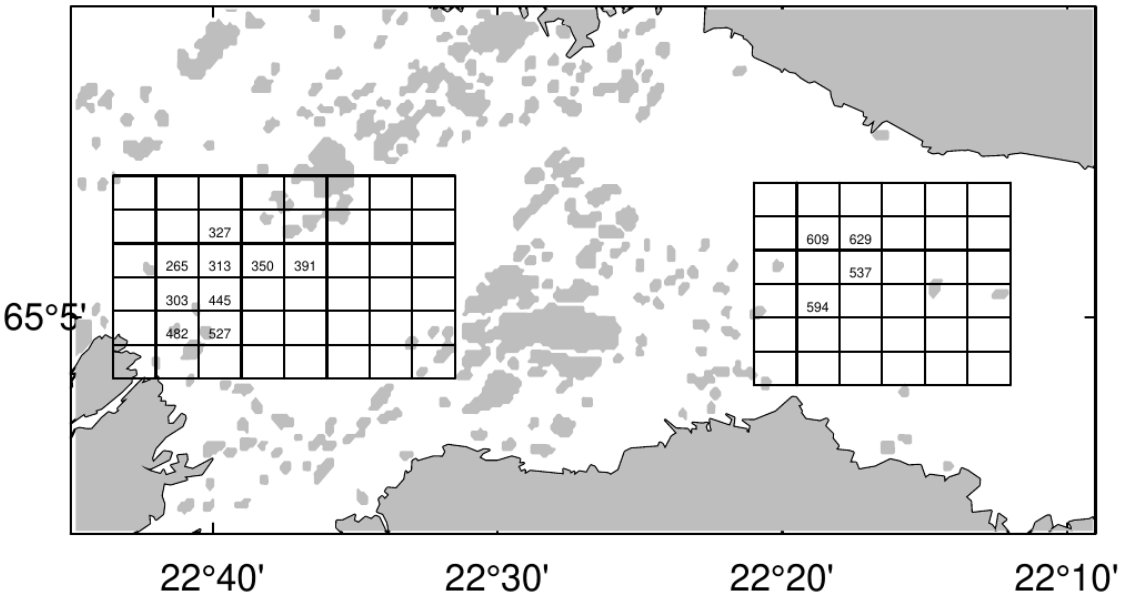

Figure 6. Iceland scallop. CPUE (kg per towed nautical mile) in southern areas during autumn of 2019, Breiðasund region on the left and Hvammsfjörður region to the right.

Mynd 6. Hörpudiskur. Yfirlit yfir afla á sóknareiningu (kg á togmílu) á suðursvæði haustið 2019. Breiðasund til vinstri og Hvammsfjörður til hægri.

During the winter 2019 it was proposed to fish 499 tonnes on seven areas with one boat. The fishing occurred in September-December and in total 452 tonnes were landed. In the northern areas fishing was according to plan in Flatey, Bjarneyjar and Rúfeyjar (Figure 3). Nothing was landed from the Látralönd and Skálmarnes areas. The CPUE in Flatey region was around 500 kg per towed nautical mile (kg/nm) (Figure 4). On most fished rectangles in Bjarneyjar, CPUE was close to 400 kg/nm. In Rúfeyjar CPUE was 504 and 410 kg/nm, respectively in the most heavily fished rectangles.

In the two southern regions, 49 tonnes were caught in Hvammsfjörður, close to the planned 48 tonnes. Fishing activities were registered mainly on one rectangle in the northwestern part of the area, or 30 tonnes (Figure 5), with CPUE of 629 kg/nm (Figure 6). In Breiðasund, 101 tonnes out of 97 tonnes planned, were caught. More than ten tonnes were caught on four rectangles (16-29 tonnes) and CPUE was between 313-445 kg/nm, respectively.

The Breiðasund region in southern Breiðafjörður has been fished now for six consecutive winters (2014-2019). The development by months on individual fishing rectangles for the years 2015-2019 is presented in Figure 7. Reduction in CPUE during the fishing season, was not always as clear in Breiðasund as in most other areas. The CPUE has fluctuated between 300-600 kg/nm, but CPUE was high in January and February of the winter of 2015/16. That catch was fished by the third boat that participated in the fishery, a smaller boat that only operated during those two months.

In Hvammsfjörður experimental fishing started in 2015 and lasted for five years (Figure 8). CPUE has fluctuated between 500 and 1000 kg/nm and usually there was a clear downward trend in CPUE over each fishing season. Highest CPUE was in 2017 but that year fishing started in the easternmost subarea in Hvammsfjörður. CPUE in 2019 was similar as the CPUE in 2015.

The Flatey region has been fished for four years, 2016-2019 (Figure 9). For the first three years CPUE started as high as 1000 kg/nm but declined to 500 kg/nm at the end of the season. Highest CPUE of 1500 kg/nm was reached in 2017 on two rectangles on a subregion in northwestern part of the area (Skeley). Sharp decline in CPUE was seen throughout the autumn of 2018. Less was fished in 2019 and CPUE was more stable or close to 500 kg/nm.

Bjarneyjar region has been fished for three years, 2017-2019 (Figure 10). The initial CPUE was close to 1000 kg/nm at the onset of the fishery. There has been almost a continuous decline throughout the whole period as the CPUE in the new fishing season starts at the same level when last season ended and then continued to decline. In 2019 the CPUE started slightly above 500 kg/nm and ended close to 400 kg/nm.

Rúfeyjar region has been fished for two years. CPUE was rather stable during the first year in 2018 and ended close to 750 kg/nm on areas fished (Figure 11). Initial values of CPUE started much lower in 2019 or below 500 kg/nm and decline was seen on most rectangles as the season progressed.

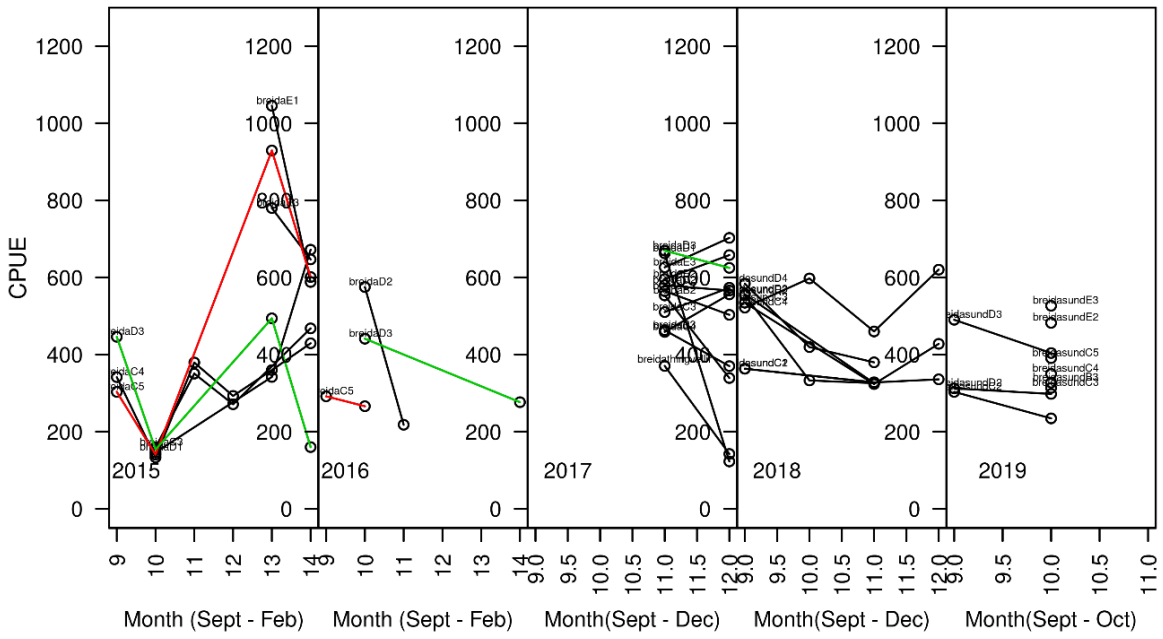

Figure 7. Iceland scallop. Development in CPUE (kg per towed mile) from September (9) to February (14) during the autumn/winter of 2015 – 2019 in Breiðasund. Rectangles within regions are plotted (a minimum of 2 tonnes caught each month).

Mynd 7. Hörpudiskur. Þróun í afla á sóknareiningu (kg á togmílu) haustin/veturna 2015-2019 eftir mánuðum frá september (9) til febrúar (14) í Breiðasundi. Sýnd eru undirsvæði þar sem að lágmarki 2 tonn voru veidd hvern mánuð.

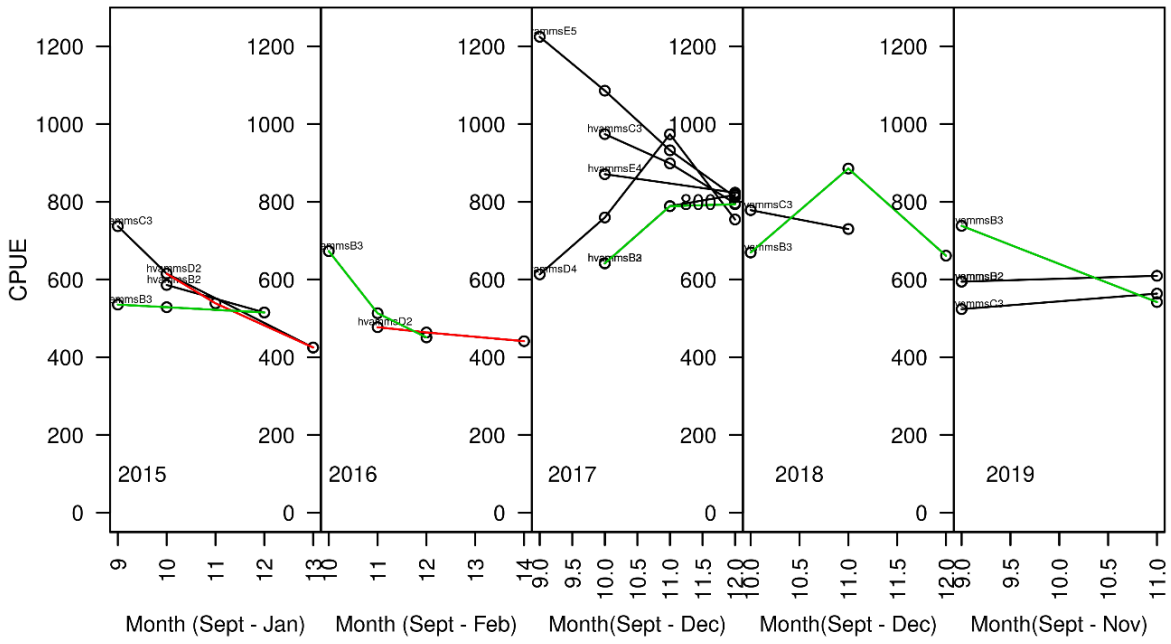

Figure 8. Iceland scallop. Development in CPUE (kg per towed mile) from September (9) to February (14) during the autumn/winter of 2015 – 2019 in Hvammsfjörður. Rectangles within regions are plotted (a minimum of 2 tonnes caught each month).

Mynd 8. Hörpudiskur. Þróun í afla á sóknareiningu (kg á togmílu) haustin/veturna 2015-2019 eftir mánuðum frá september (9) til febrúar (14) í Hvammsfirði. Sýnd eru undirsvæði þar sem að lágmarki 2 tonn voru veidd hvern mánuð.

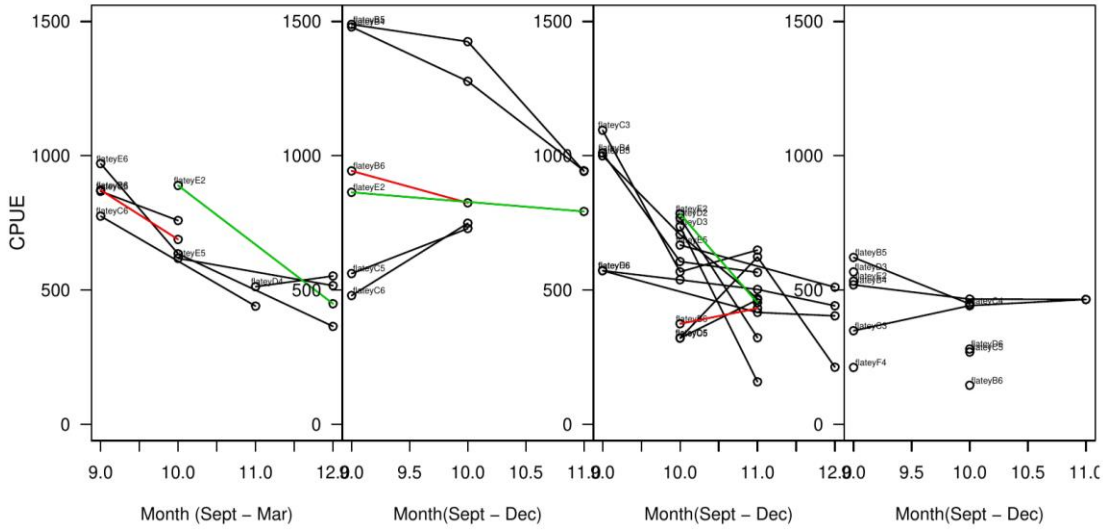

Figure 9. Iceland scallop. Development in CPUE (kg per towed mile) from September (9) to December (12) during the autumn/winter of 2016 – 2019 in Flatey area. Rectangles within regions are plotted (a minimum of 2 tonnes caught each month).

Mynd 9. Hörpudiskur. Þróun í afla á sóknareiningu (kg á togmílu) haustin/veturna 2016-2019 eftir mánuðum frá september (9) til desember (12) vestur af Flatey. Sýnd eru undirsvæði þar sem að lágmarki 2 tonn voru veidd hvern mánuð.

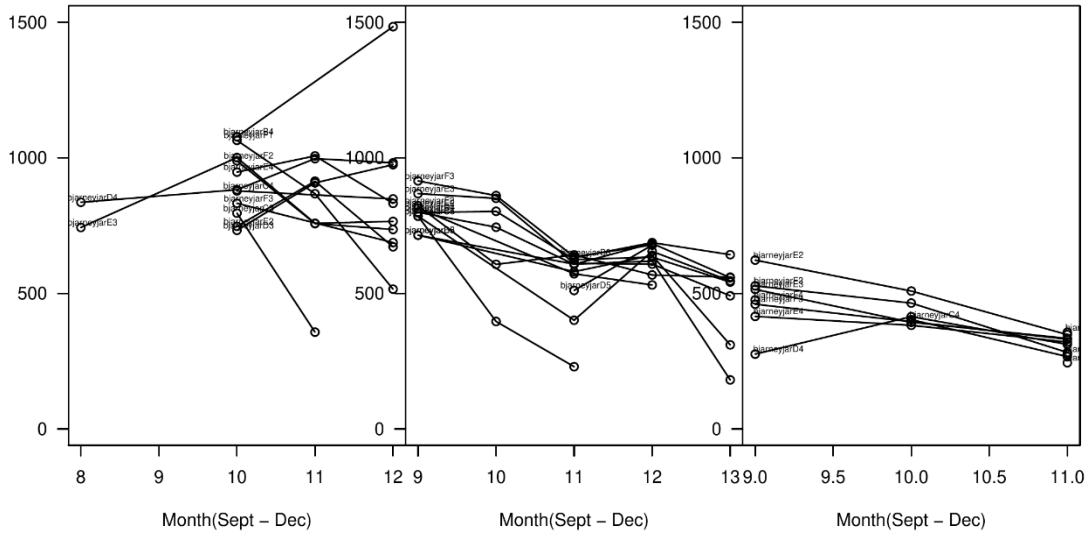

Figure 10. Iceland scallop Development in CPUE (kg per towed mile) from September (9) to January (13) during the autumn/winter of 2017 – 2019 in Bjarneyjar area. Rectangles within regions are plotted (a minimum of 2 tonnes caught each month).

Mynd 10. Hörpudiskur. Þróun í afla á sóknareiningu (kg á togmílu) haustin/veturna 2017-2019 eftir mánuðum frá september (9) til janúar (13) við Bjarneyjar. Sýnd eru undirsvæði þar sem að lágmarki 2 tonn voru veidd hvern mánuð.

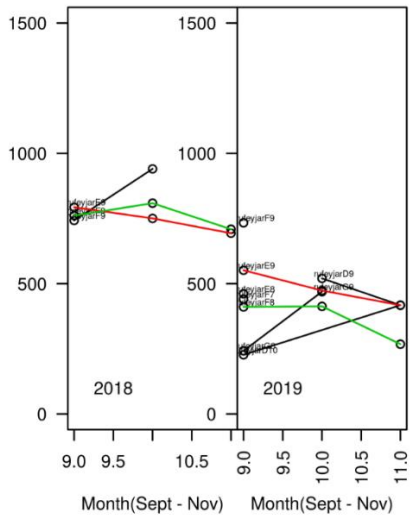

Figure 11. Iceland scallop. Development in CPUE (kg per towed mile) from September (9) to November (11) during the autumn 2018 – 2019 in Rúfeyjar area. Rectangles within regions are plotted (a minimum of 2 tonnes caught each month).

Mynd 11. Hörpudiskur. Þróun í afla á sóknareiningu (kg á togmílu) haustin 2018-2019 eftir mánuðum frá september (9) til nóvember (11) við Rúfeyjar. Sýnd eru undirsvæði þar sem að lágmarki 2 tonn voru veidd hvern mánuð.

SURVEY INDICES

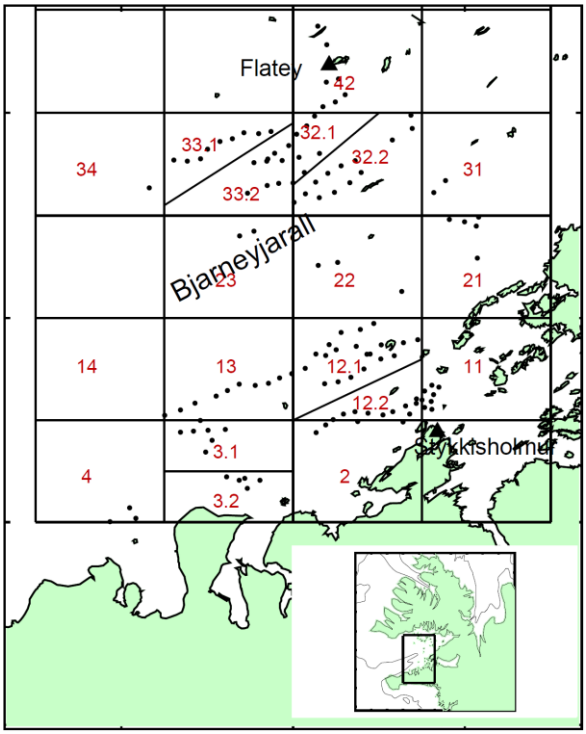

Figure 12. Iceland scallop. Overview of the dredge survey tows (dots) in Breiðafjörður, red numbers area the subareas used and the boxes the outlines of them. The town of Stykkishólmur and Flatey are marked with triangles.

Mynd 12. Hörpudiskur. Yfirlitskort af stöðvum (punktar) úr plóg-leiðöngrum í Breiðafirði. Reitaskiptingin táknar undirsvæði sem notuð eru við stofnstærðarútreikninga (rauð númer). Stykkishólmur og Flatey eru merkt inn á kortið með þríhyrningum.

DREGDE SURVEY 1977-2013

Biomass survey with dredge was conducted by the Marine Research Institute (MRI) in Breiðafjörður almost from the onset of the fishery until 2013. In each survey, usually some 120 fixed standardized tows were taken. However, in later years fewer stations were occupied with shorter tows. In 2012 the southern, and in 2013 the northern part of the fjord was surveyed. Prior to 1997, a 470 kg sledge dredge 1.5 m wide was used. In 1998, the sledge dredge was substituted with an 835 kg roller dredge 1.2 m wide (Guijarro Garcia, 2006). Both dredges were equipped with 60 mm steel rings. Earlier experiments on the sledge dredge had revealed an efficiency of 20% (e = 0.2). Comparative experiments between the roller and sledge dredge showed that the catch of scallops in roller dredge tows was on average 30% higher than in sledge tows, so e for the roller dredge was set at 0.26 (n = 46, MFRI, unpublished data).

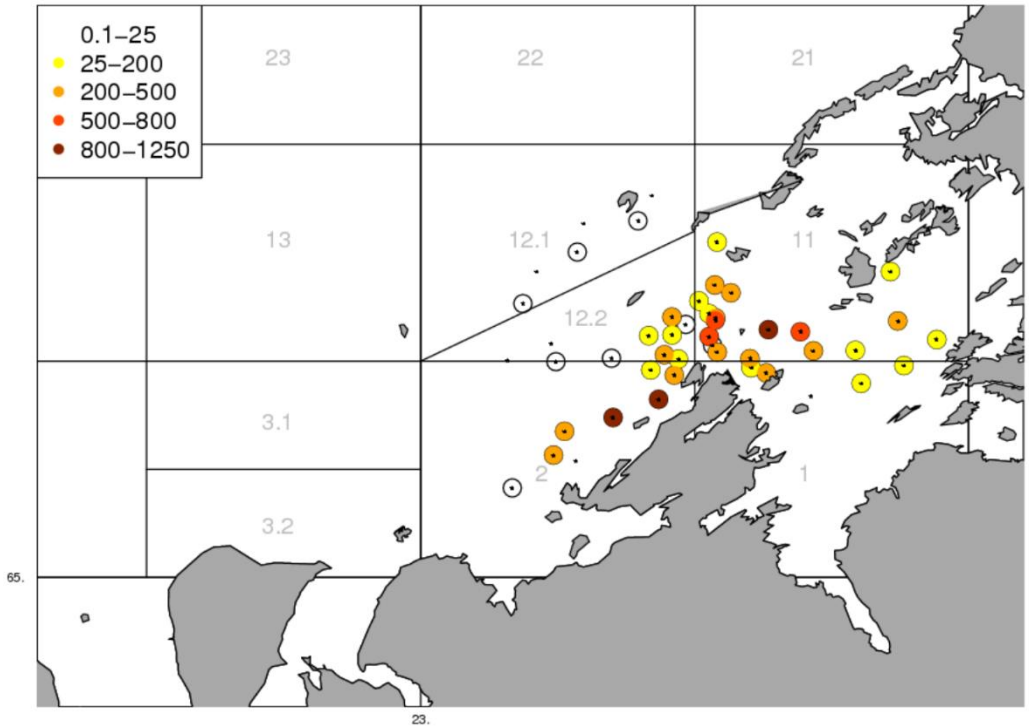

Figure 13. Iceland scallop. Catch of scallops (kg) per towed mile during dredge survey of the southern part of Breiðafjörður in 2012. Small dots represent stations with no scallops, but rings show stations with scallop catch according to the color scale. Black grids are the subareas marked with grey numbers.

Mynd 13. Hörpudiskur. Afli hörpudisks (kg) á hverja dregna sjómílu í plógleiðangri í suðurhluta Breiðafjarðar árið 2012. Litlir punktar sýna stöðvar með engum hörpudisk og litir innan hringja tákna magn skv. kvarða. Reitaskipting er sýnd og heiti reita (gráar tölur).

Each survey tow covered approximately 0.4 nautical miles and the tow speed was 4 knots. For each tow, the total catch was weighed and a random subsample of approximately 25 kg taken. In each subsample, all live scallops were weighed and the height of about 100 specimens was recorded. The remaining scallops were counted and the numbers of cluckers (dead scallops attached on their hinges, both damaged and whole shells) were recorded.

The survey area was divided into subareas, based on a grid of squares of equal size. Squares positioned on the main scallop grounds were split into two subareas (Figure 12). The total region fished was divided into a northern area (subareas 31–42), north of Bjarneyjaáll (a trench bisecting the fjord from west to east), and a southern area (subareas 2 –14), south of the trench. The size of the scallop beds in each subarea was based on estimates conducted at the beginning of the surveys in the early 1970s, where the total area was estimated to be 72 km^2. See further information of the calculation of the stock index in Jonasson, *et al.* (2007).

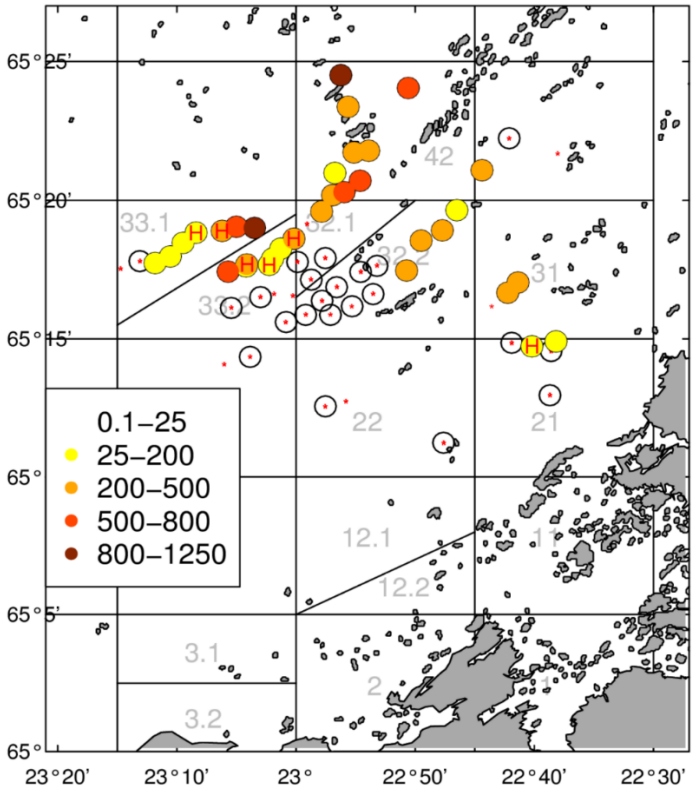

Figure 14. Iceland scallop. Catch of scallops (kg) per towed mile during dredge survey of the northern part of Breiðafjörður in 2013. Small dots represent stations with no scallops, but rings show stations with scallop catch according to the color scale. Black grids are the subareas marked with grey numbers. Red H marks stations with more than 10% cluckers/scallop ratio.

Mynd 14. Hörpudiskur. Afli hörpudisks (kg) á hverja dregna sjómílu í plógleiðangri í norðurhluta Breiðafjarðar árið 2013. Litlir punktar sýna stöðvar með engum hörpudisk og litir innan hringja tákna magn skv. kvarða. Reitaskipting er sýnd og heiti reita (gráar tölur). Rautt H stendur fyrir stöðvar með meira en 10% af skeljum á hjör.

The stock index of Iceland scallop in Breiðafjörður was relatively stable from 1993 to 1999, but it declined sharply from 2000 to 2003. In 2003 (23 000 t), it was at a historically low level or at 30% of the average stock

size during the 1990s. This declining trend continued until 2006, and since then the index slowly decreased until the last value of combined surveys of 2012 and 2013 (Figures 2, 13 & 14).

The trend in shell height frequency has been that the ratio of scallop >65 mm has increased and in 2013 there was high proportion of scallops >80 mm (Figure 15). Small scallops were hardly seen until 2012 in the southern part of the fjord (Figure 16). Year-classes from 2004–2009 are poorly visible in the stock.

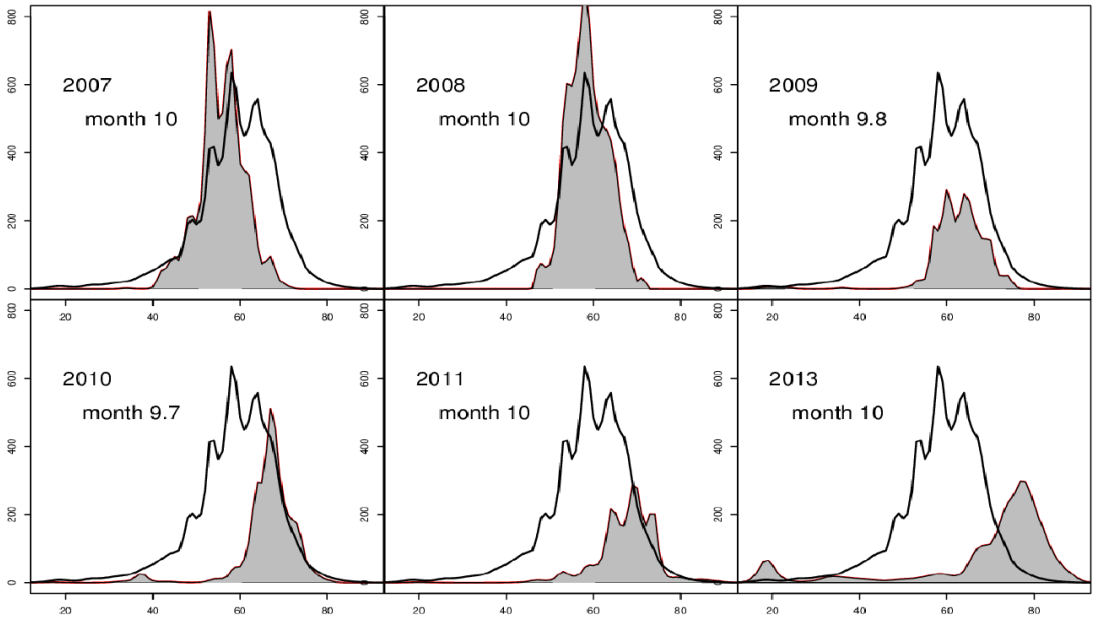

Figure 15. Iceland scallop. Frequency distribution of scallop shell height (mm), mean numbers per towed mile, from subarea 33.1 (south of Oddbjarnarsker) during 2007–2011 and in 2013. Grey filled area is the distribution of individual year and the black line is the mean of 1993–2013.

Mynd 15. Hörpudiskur. Hæðardreifing (mm) hörpudisks frá reit 33.1 (suður af Oddbjarnarskeri) frá 2007–2011 og 2013.Tölurnar eru meðalfjöldi skelja á togmílu. Gráa svæðið er umrætt ár og svartar línur eru meðaltal áranna 1993–2013.

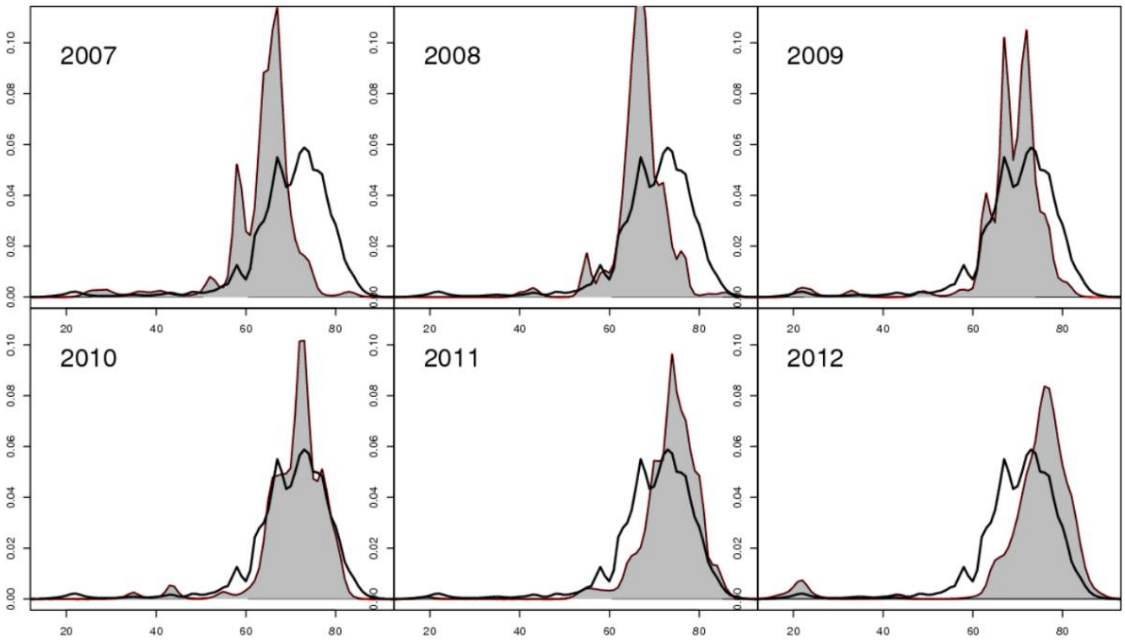

Figure 16. Iceland scallop. Relative size frequency distribution (%) of scallops from subarea 2 (west of Stykkishólmur) during 2007–2012. Grey filled area is the distribution of individual year and the black line is the mean of 1993–2012.

Mynd 16. Hörpudiskur. Hlutfallsleg hæðardreifing (mm) hörpudisks frá reit 2 (vestur af Stykkishólmi) frá 2007–2012. Gráa svæðið er umrætt ár og svartar línur eru meðaltal áranna 1993–2012.

CAMERA SURVEY 2014 – 2019

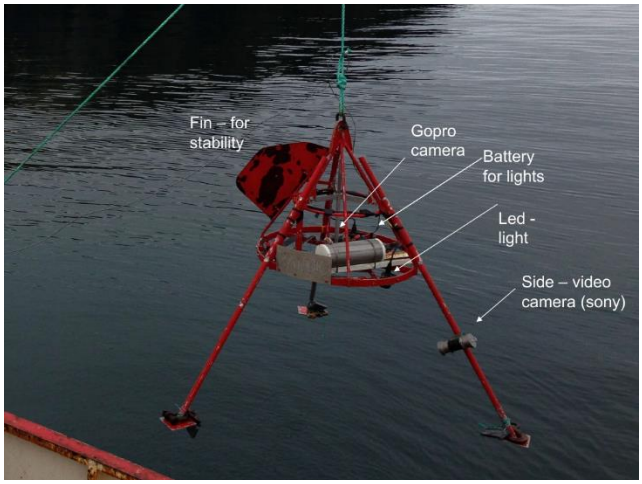

Figure 17. Iceland scallop. The first camera drop frame used for mapping scallop populations in Breiðafjörður.

Figure 17. Hörpudiskur. Mynd af fyrsta þrífætinum sem notaður var við kortlagningu hörpudisks í Breiðafirði.

A drop frame camera survey has been conducted on scallop grounds in Breiðafjörður since 2014 (Figure 17). Stokesbury (2012) discussed some of the advantages that the video/camera survey technique has over conventional dredge survey and stated that the new method is a direct measure of absolute abundance

versus a semi-quantitative one. It is more precise, rather fast and nonintrusive. These are the main reasons why the MFRI has changed from a dredge survey to a camera survey.

Several tows with dredge are also carried out to get information on shell height and biological samples. Ten camera "drops" are completed on each station and the general rule is to count every other drop or five drops in total. In the camera survey all animals are counted, and the area of the image is known. Scallops have been measured from images since 2018. It could be expected to see higher percentage of small scallops in images than from the dredge due to gear selection. When calculating the ratio of undersized or small scallops, scallops less than 25 mm are excluded. Those small scallops tend to be cryptic and difficult to see when counting from images. Biomass is estimated from number of scallops above 60 mm, based on size distribution from dredges and SH/weight relationship multiplied with the estimated size of fishable grounds.

In April 2014, a pilot camera survey focused mainly on the Breiðasund area in the southern part of the fjord, where experimental fishing had been planned. There were also stations on conventional fishing grounds in the southern area, Sundin (subarea 12.2), and the area between Höskuldsey and Elliðaey (subarea 12.1). In total 146 station were completed. New and grounds that were not covered with the older dredge survey were also surveyed. Those were in Hvammsfjöður, south of Skálmarnes, west of Látralönd and around Sauðeyjar in northwestern part of the fjord. Large numbers of scallops were found on many of the "new" grounds. Another survey was conducted in December 2014 and covered the area that was fished in the experimental fishing in Breiðasund.

During autumn 2015–2019, camera surveys were carried out annually on most of the experimental fishing areas and also on other scallop grounds within Breiðafjörður. In this report, result from experimental areas fished in 2019, Breiðasund, Hvammsfjörður, Bjarneyjar, Rúfeyjar and Flatey will be presented.

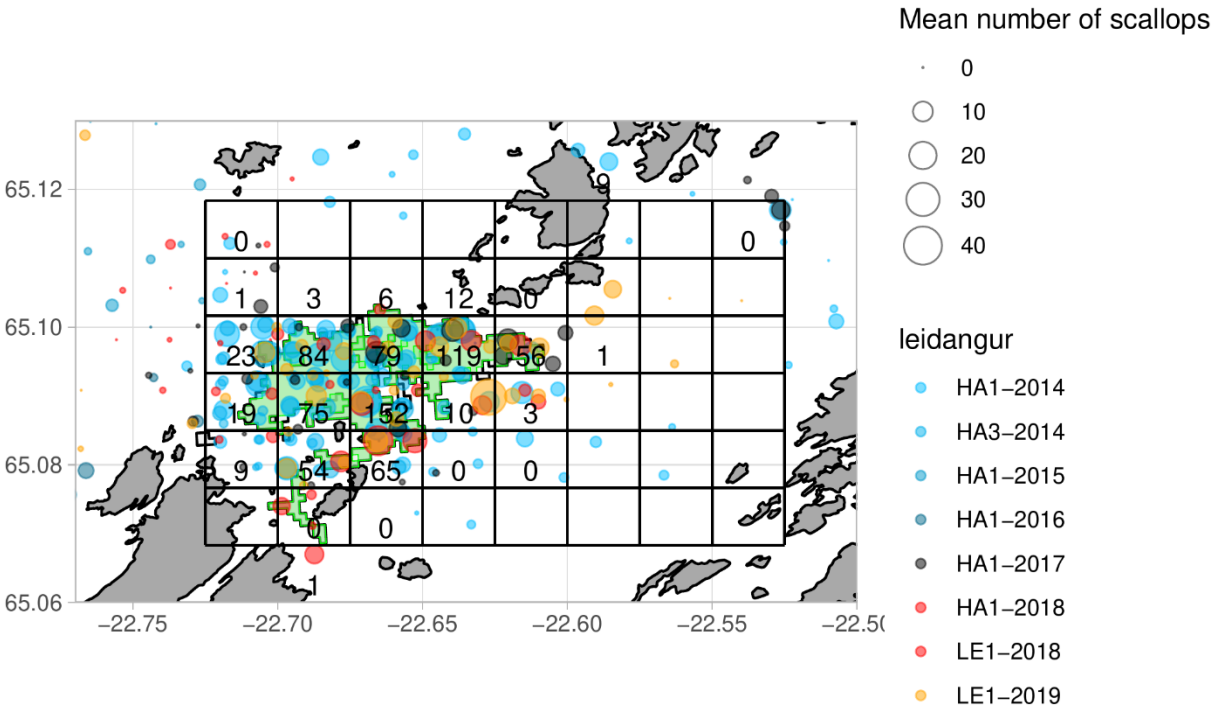

Figure 18. Iceland scallop. Camera surveys stations in Breiðasund southern Breiðafjörður, during surveys (leidangur) in 2014-2019. The size of the circles represents the number of scallops (m²). The number represent cumulative catches in tonnes.

Mynd 18. Hörpudiskur. Stöðvar í myndavélaleiðöngrum í Breiðasundi suðurhluta Breiðafjarðar árin 2014-2019. Stærð hringja táknar fjölda hörpudiska (m²) skv. kvarða. Tölurnar í hverjum reit tákna uppsafnaðann afla í tonnum.

Within in Breiðasund in southern Breiðafjörður, fishing activity was mainly in western and middle part of conventional grounds (Figure 18). The estimated size of fishing grounds, based on VMS data, was the largest of all or 5.64 km^2 (Table 3). The greatest amount of scallop was seen in April of 2014, 8.86 scallops m^2 within the fished ground (Figures 18 & 20) and biomass of 3000 tonnes (Table 3). The average number of scallops dropped considerable after fishing of 280 tonnes during the autumn of 2014, or to 6.24 scallops m^2. The ground was surveyed again during 2017-2019, and estimated scallop abundance fluctuated between 5.31–6.64 scallops m^2. Estimated harvest rate was 9% in 2014 and 2017, but declined to 5.6% and 6.9% during 2018 and 2019, respectively (Table 4). Highest mean shell height was in April 2014, 76.1 mm, with peak in old scallops around 80 mm and another peak of 2-3-year old scallops of 15-25 mm (Table 3 and Figure 21). A proportion of those young scallops had entered the fishable the stock (+60 mm) during the autumn of 2016. With increasing recruitment, the average shell height decreased in 2017 and 2018. Highest ratio of small scallops was 11.9% in 2018. Both during 2018 and especially in 2019, considerable higher abundance of small scallops was seen with the camera then found in the dredge samples (Figure 21).

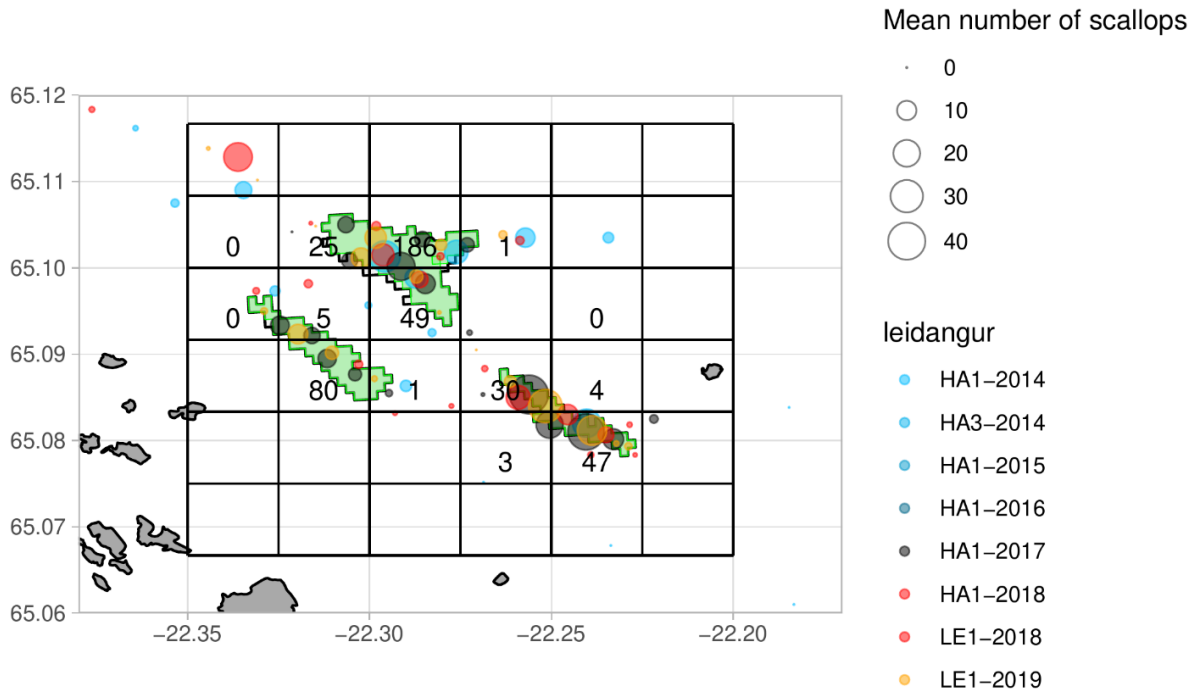

Figure 19. Iceland scallop. Camera surveys stations in Hvammsfjörður southern Breiðafjörður, during surveys (leidangur) in 2014-2019. The size of the circles represents the number of scallops (m²). The number represent cumulative catches in tonnes.

Mynd 19. Hörpudiskur. Stöðvar í myndavélaleiðöngrum í Hvammsfirði suðurhluta Breiðafjarðar árin 2014-2019. Stærð hringja táknar fjölda hörpudiska (m²) skv. kvarða. Tölurnar í hverjum reit tákna uppsafnaðann afla í tonnum.

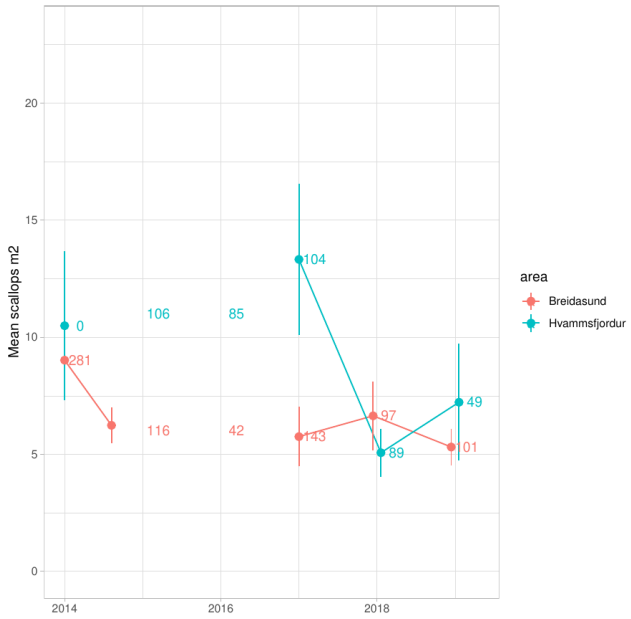

Figure 20. Iceland scallop. Mean number of scallops (m², with SE) per m² on dredged grounds, in surveys in Breiðasund and Hvammsfjörður. Tonnes caught during following winter on each area is also plotted.

Mynd 20. Hörpudiskur. Meðalfjöldi hörpudiska (með staðalskekkju) á fermetra á stöðvum á veiðislóð í myndavélaleiðöngrum í Breiðasundi og Hvammsfirði. Veidd tonn á hverjum vetri eru einnig teiknuð inn á grafið.

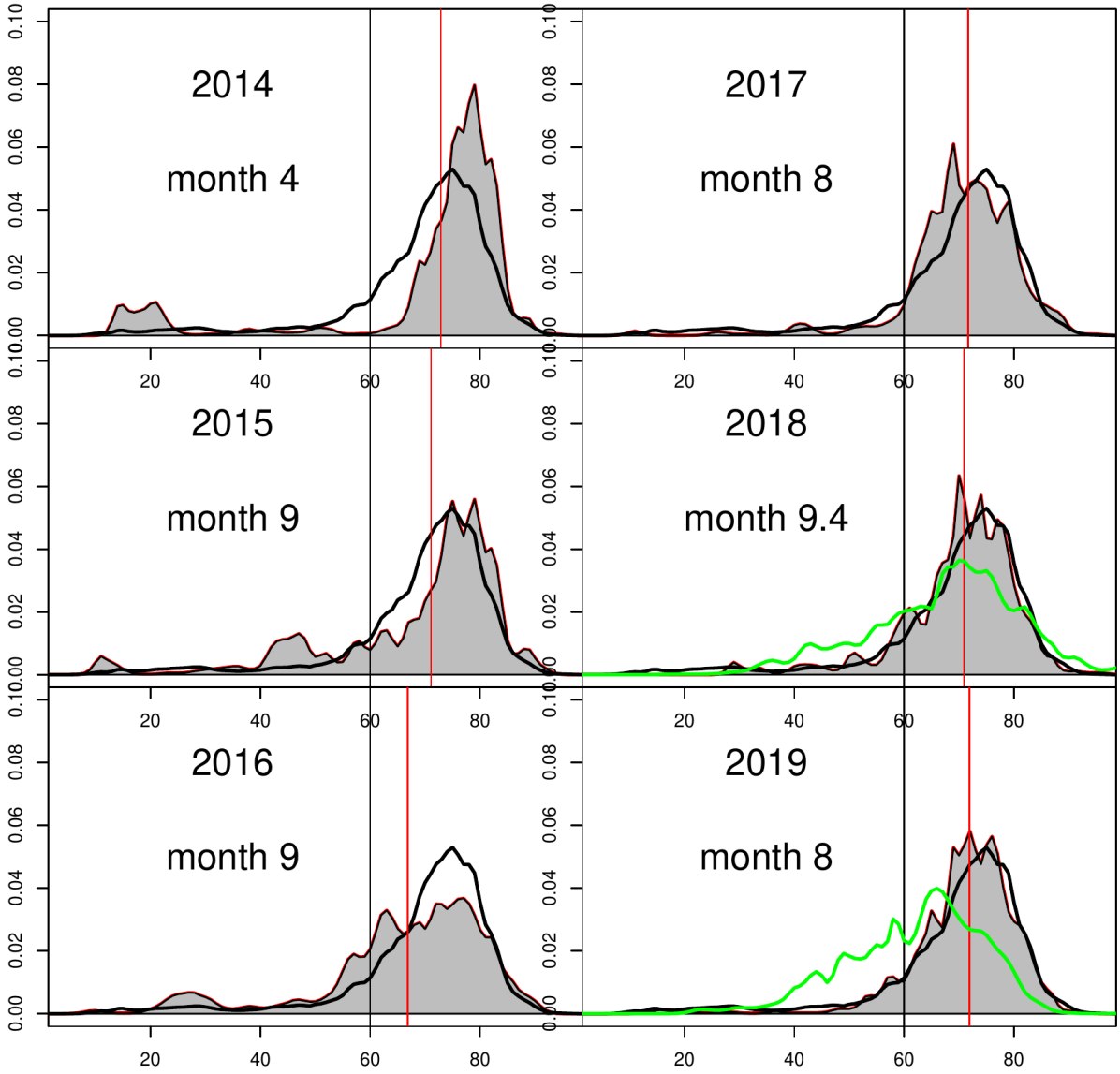

Figure 21. Iceland scallop. Relative size frequency distribution (%) of scallops from experimental fishing area in Breiðasund (east of Stykkishólmur) during 2014–2019. Grey filled area is the distribution of individual year and the black line is the mean of the period. Black vertical line is set at 60 mm which is the minimal landing size and red vertical line is the mean length of each year. Green lines for years 2018 and 2019 are length frequency distributions derived from images within fished grounds in Breiðasund.

Mynd 21. Hörpudiskur. Hlutfallsleg hæðardreifing (mm) hörpudisks úr tilraunareit í Breiðasundi (austur af Stykkishólmi) frá 2014–2019. Gráa skyggða svæðið er umrætt ár og svartar línur eru meðaltal áranna sem eru sýnd. Svört lóðrétt lína er sett við 60 mm sem er lágmarkslöndunarstærð og rauð lóðrétt lína er meðaltal hvers árs. Grænar línur árin 2018 og 2019 eru lengdardreifing fengin af botnmyndum.

Within Hvammsfjörður in southeastern Breiðafjörður, fishing activity was on three subareas, two on the northern slope of the fjord and one on the southern slope (Figure 19). The estimated size of fishing grounds, based on VMS data, was 2.34 km^2 (Table 4). The greatest amount of scallop was seen in 2017, 13.32 scallops m^2 within the fished grounds (Figure19 & 20) and biomass of 1341 tonnes (Table 4).

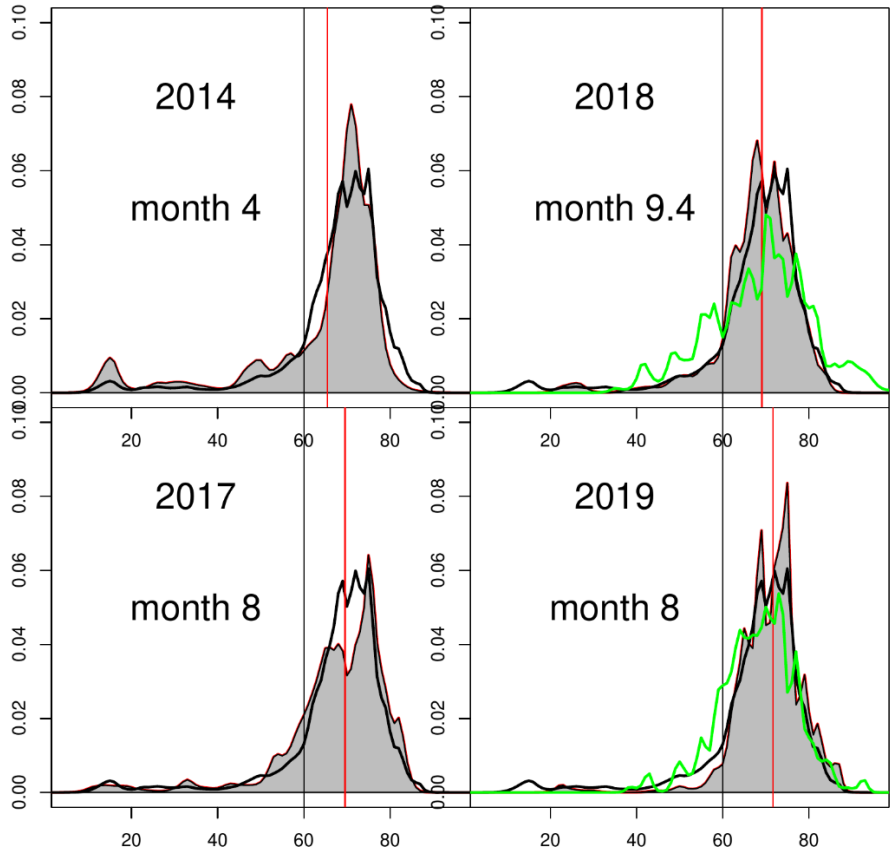

Figure 22. Iceland scallop. Relative size frequency distribution (%) of scallops from experimental fishing area in Hvammsfjörður during 2014–2019. Grey filled area is the distribution of individual year and the black line is the mean of the period. Black vertical line is set at 60 mm which is the minimal landing size and red vertical line is the mean length of each year. Green lines for years 2018 and 2019 are length frequency distributions derived from images within fished grounds in Breiðasund.

Mynd 22. Hörpudiskur. Hlutfallsleg hæðardreifing (mm) hörpudisks úr tilraunareit í Hvammsfirði frá 2014–2019. Gráa skyggða svæðið er umrætt ár og svartar línur eru meðaltal áranna sem eru sýnd. Svört lóðrétt lína er sett við 60 mm sem er lágmarkslöndunarstærð og rauð lóðrétt lína er meðaltal hvers árs. Grænar línur árin 2018 og 2019 eru lengdardreifing fengin af botnmyndum.

The average number of scallops fluctuated considerable in the area, it declined to 5.07 scallops in 2018 but increased to 7.22 scallops m^2 in 2019. Estimated harvest rate was 10.7% in 2015 (based on biomass estimates of 2014, Table 4). The harvest rate was 7,8% in 2017, but increased considerable in 2018 to 17,7% coinciding with the low abundance index. There was a reduction in catches in 2019 but also increase in abundance that resulted in harvest rate of 6%. Lowest mean shell height was in 2014, 67.1 mm, with a single peak of old scallops at 70 mm, but several younger year-classes (Figure 22). There was high ratio of small scallops (16.3%) a peak of two year's old scallop around 15 mm and one prominent peak around 50 mm (Table 4). A proportion of those young scallop had entered the fishable the stock (+60 mm) during the autumn of 2017. Average shell heights increased and was 71.2 mm in 2019, but there was also lower ratio of small scallops in the dredge samples. Shell height estimated from images revealed higher abundance of scallops slightly smaller than 60 mm in 2018 and proportionally higher abundance of scallops slightly higher than 60 mm in 2019 (Figure 22).

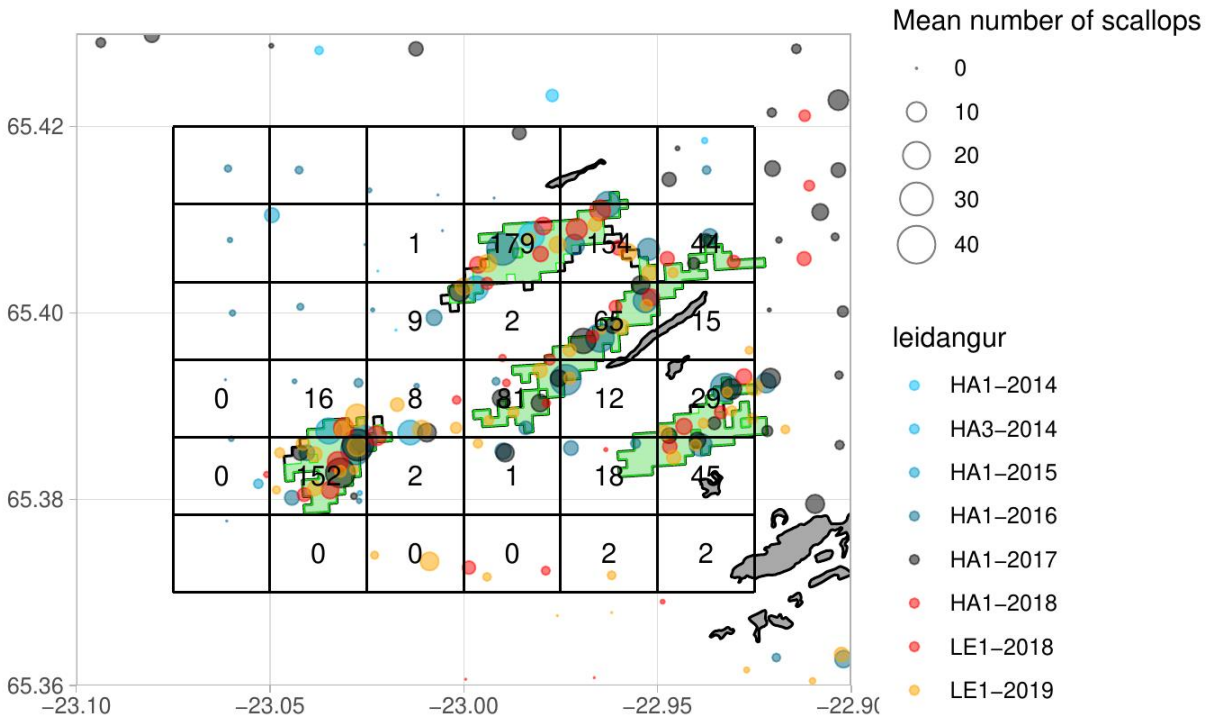

Figure 23. Iceland scallop. Camera surveys stations in Flatey area northern Breiðafjörður, during surveys (leidangur) in 2014-2019. The size of the circles represents the number of scallops (m²). The number represent cumulative catches in tonnes.

Mynd 23. Hörpudiskur. Stöðvar í myndavélaleiðöngrum vestur af Flatey í norðurhluta Breiðafjarðar árin 2014-2019. Stærð hringja táknar fjölda hörpudiska (m²) skv. Kvarða Tölurnar í hverjum reit tákna uppsafnaðann afla í tonnum.

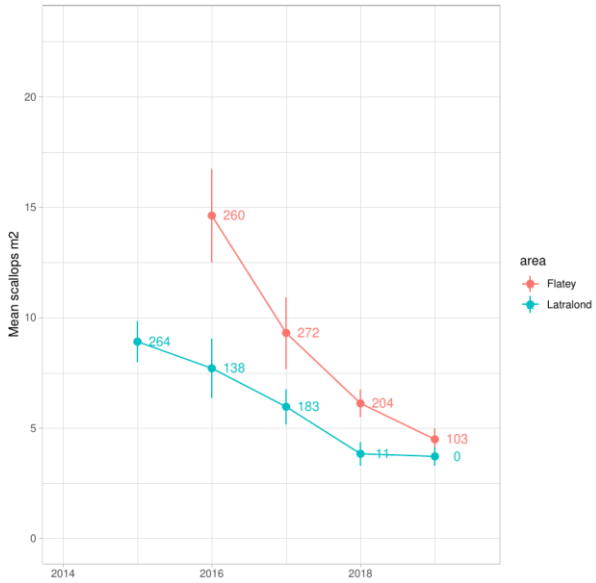

Figure 24. Iceland scallop. Mean number of scallops (m², with SE) per m² on dredged grounds, in surveys in Flatey area and Látralönd. Tonnes caught during following winter on each area is also plotted.

Mynd 24. Hörpudiskur. Meðalfjöldi hörpudiska (með staðalskekkju) á fermetra á stöðvum á veiðislóð í myndavélaleiðöngrum við Flatey og Látralöndum. Veidd tonn á hverjum vetri eru einnig teiknuð inn á grafið.

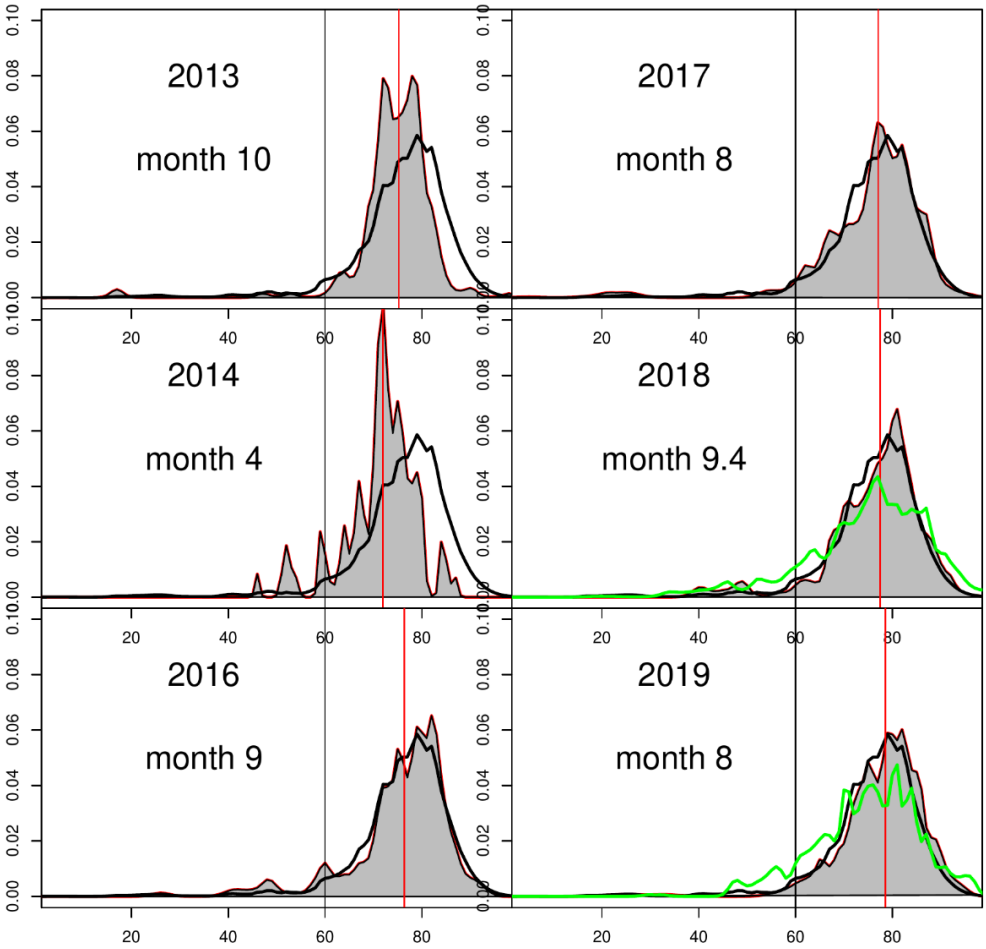

Figure 25. Iceland scallop. Relative size frequency distribution (%) of scallops from experimental fishing area in Flatey area during 2013–2019. Grey filled area is the distribution of individual year and the black line is the mean of the period. Black vertical line is set at 60 mm which is the minimal landing size and red vertical line is the mean length of each year. Green lines for years 2018 and 2019 are length frequency distributions derived from images within fished grounds in Breiðasund.

Mynd 25. Hörpudiskur. Hlutfallsleg hæðardreifing (mm) hörpudisks úr tilraunareit í Flatey frá 2013 –2019. Gráa skyggða svæðið er umrætt ár og svartar línur eru meðaltal áranna sem eru sýnd. Svört lóðrétt lína er sett við 60 mm sem er lágmarkslöndunarstærð og rauð lóðrétt lína er meðaltal hvers árs. Grænar línur árin 2018 og 2019 eru lengdardreifing fengin af botnmyndum.

In Flatey region in northern Breiðafjörður, fishing activity was recorded on four major subareas (Figure 23). The estimated size of fishing grounds, based on VMS data, was 3.83 km^2 (Table 5). The was a continuous decline in scallop abundance from 14.62 scallops m^2 in 2016 to 4.5 scallops m^2 in 2019 (Figure 23 & 24 and Table 5). Estimated harvest rate was 7.8% in 2016 (Table 5). The harvest rate was high in 2017 and 2018 or 12.3% and 14.0%, respectively. Coinciding with reduction in catches but also with reduction in the abundance index, harvest rate was 9.1% in 2019. There was a continuous increase in shell height from 2013–2019, with average shell height in 2019, 78.1 mm (Figure 25). That is also reflected in the ratio of small scallop that has decreased from 7.3% to 2.1% between 2016-2019 (Table 5). Shell height estimated from images revealed slightly higher abundance of scallops slightly smaller than 60 mm and between 60 and 65 mm in 2019 (Figure 25).

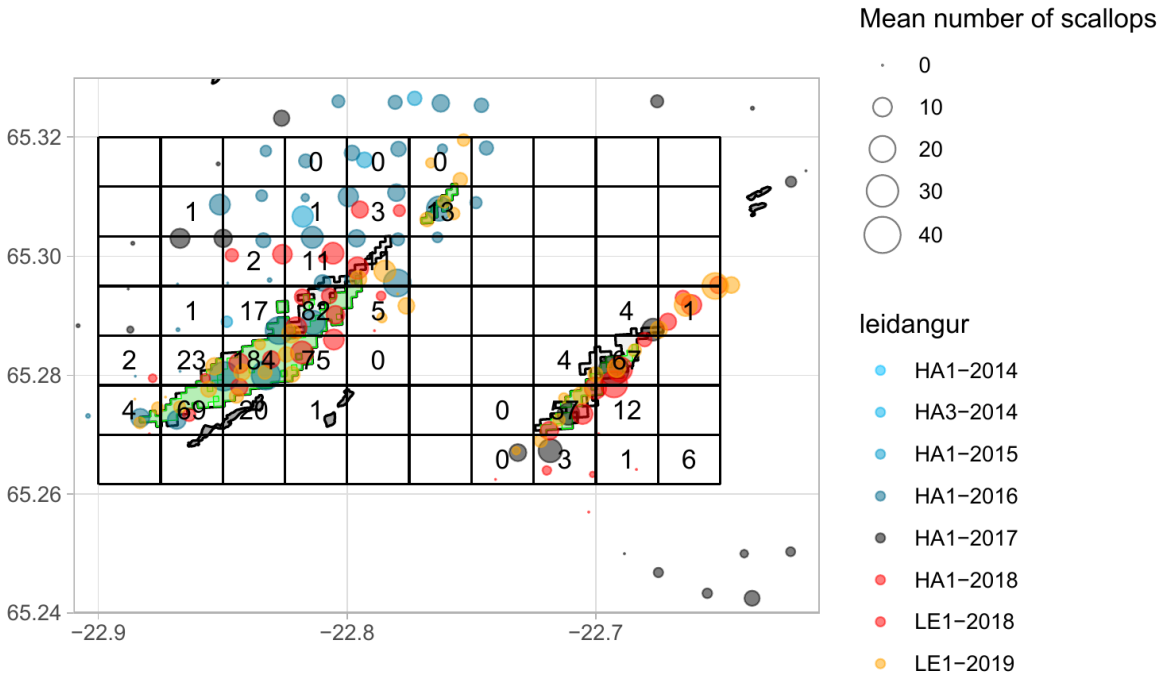

Figure 26. Iceland scallop. Camera surveys stations in Bjarneyjar (left) and Rúfeyjar (right) areas in Breiðafjörður, during surveys (leidangur) in 2014-2019. The size of the circles represents the number of scallops (m²). The number represent cumulative catches in tonnes.

Mynd 26. Hörpudiskur. Stöðvar í myndavélaleiðöngrum við Bjarneyjar (vinstra megin) og Rúfeyjar (hægra megin) í Breiðafirði árin 2014-2019. Stærð hringja táknar fjölda hörpudiska (m²) skv. kvarða. Tölurnar í hverjum reit tákna uppsafnaðann afla í tonnum.

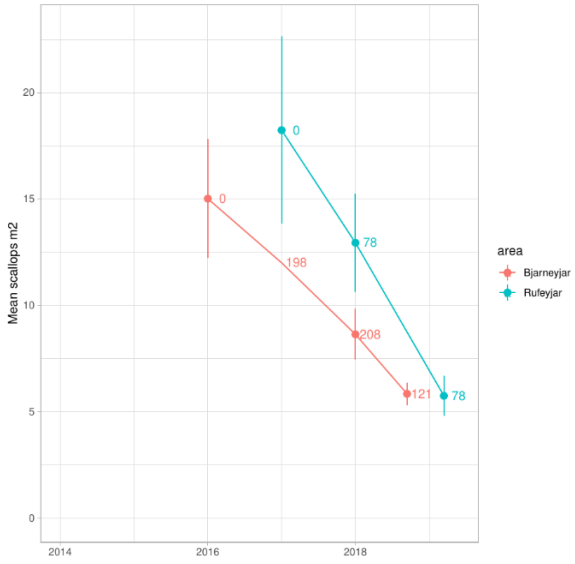

Figure 27. Iceland scallop. Mean number of scallops (m², with SE) per m² on dredged grounds, in surveys in Bjarneyjar and Rúfeyjar. Tonnes caught during following winter on each area is also plotted.

Mynd 27. Hörpudiskur. Meðalfjöldi hörpudiska (með staðalskekkju) á fermetra á stöðvum á veiðislóð í myndavélaleiðöngrum við Bjarneyjar og Rúfeyjar. Veidd tonn á hverjum vetri eru einnig teiknuð inn á grafið.

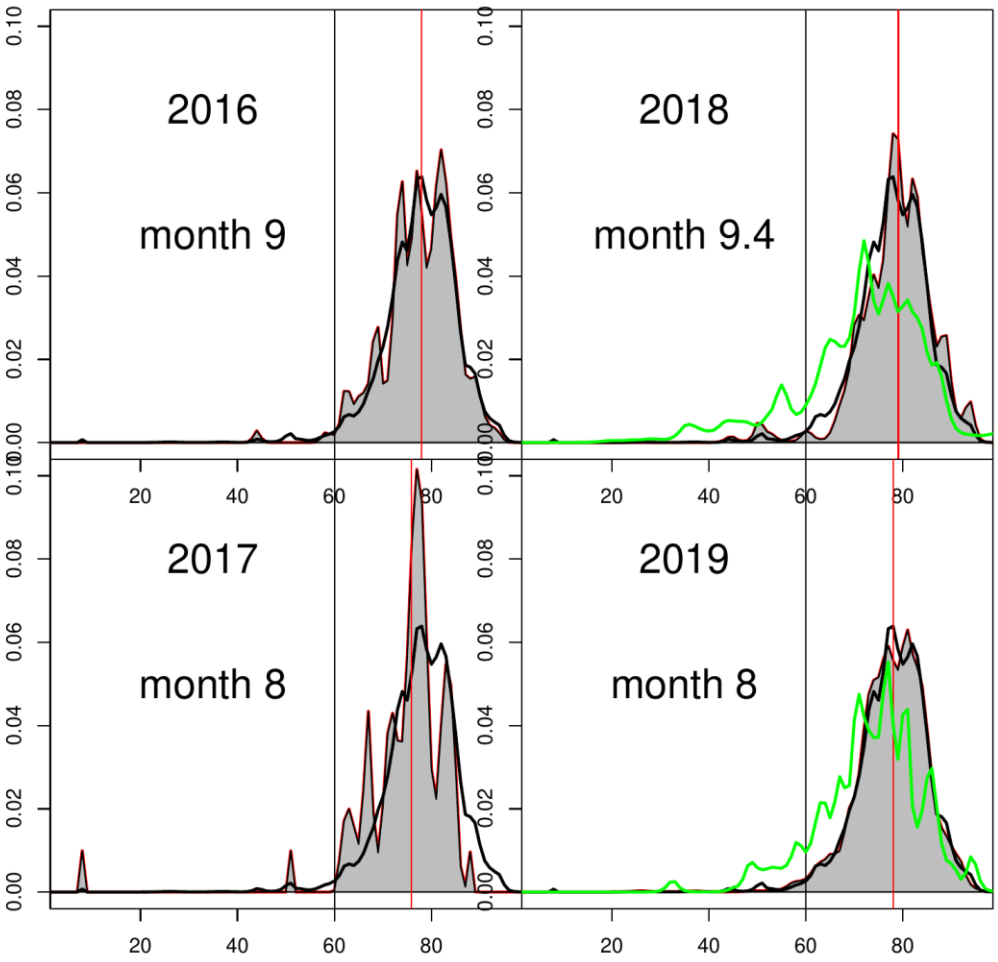

Figure 28. Iceland scallop. Relative size frequency distribution (%) of scallops from experimental fishing area in Bjarneyjar during 2016–2019. Grey filled area is the distribution of individual year and the black line is the mean of the period. Black vertical line is set at 60 mm which is the minimal landing size and red vertical line is the mean length of each year. Green lines for years 2018 and 2019 are length frequency distributions derived from images within fished grounds.

Mynd 28. Hörpudiskur. Hlutfallsleg hæðardreifing (mm) hörpudisks úr tilraunareit við Bjarneyjar frá 2016 –2019. Gráa skyggða svæðið er umrætt ár og svartar línur eru meðaltal áranna sem eru sýnd. Svört lóðrétt lína er sett við 60 mm sem er lágmarkslöndunarstærð og rauð lóðrétt lína er meðaltal hvers árs. Grænar línur árin 2018 og 2019 eru lengdardreifing fengin af botnmyndum.

In Bjarneyjar region in northern Breiðafjörður, fishing activity was mainly recorded on one large area, that stretched to couple of smaller area to the north east (Figure 26). The estimated size of fishing grounds, based on VMS data, was 3.26 km^2 (Table 6). The was a continuous decline in scallop abundance on fishing ground from 15.02 scallops m^2 in 2016 to 5.84 scallops m^2 in 2019 (Figure 26 & 27 and Table 6). Estimated harvest rate was 6.4% in 2017 (based on biomass estimates of 2016, Table 6). The harvest rate increased to 11.1% in 2018. There was a reduction in catches in 2019 but also increase in abundance that resulted in harvest rate of 9,7%. There were little changes in mean shell height from 2016 – 2019, with average shell height around 78 mm (Figure 28). That is also reflected in low ratio (1-2%) of small scallops in the area

(Table 6). Shell height estimated from images revealed slightly higher abundance of scallops between 50 – 70 mm for both 2018 and 2019 (Figure 28).

In Rúfeyjar region in northern Breiðafjörður, fishing activity was recorded on one relatively thin strip (Figure 26). The estimated size of fishing grounds, based on VMS data, was 1.05 km^2 (Table 7). The was a continuous decline in scallop abundance from 18.24 scallops m^2 in 2017 to 5.75 scallops m^2 in 2019 (Figure 26 & 27 and Table 7). However, no fishing took place in 2017, but the variance of the 2017 abundance estimate was high. Estimated harvest rate was 9.2% in 2018 (Table 7). The harvest rate increased to 20.6% in 2019, coinciding with the reduction in abundance index. There were little changes in mean shell height from 2017 – 2019, with average shell height around 77 mm (Table 7). The ratio of small scallop was low in Rúfeyjar region (~1%, Table 7).

ADVICE

Throughout the period 1993–2000, the total allowable catch (TAC) in Breiðafjörður was relatively stable at about 8000-8500 tonnes (Table 1). At that time, the recommended annual TAC was 10% of the total estimated biomass from dredge surveys; since 1994, the national TAC and the landings have been in accord with the recommendations. Between 2003 and 2013 the MRI advised that no fishery should be conducted on scallop grounds in Breiðafjörður. In 2014 the advice was no fishery on conventional grounds, but small-scale fishing experiments were allowed in areas outside the limits of the dredge survey. The same advice has been given in 2015-2019 and fishing trials continued, mainly on new grounds, but later also on traditional grounds were scallops are found in fishable quantities.

The lesson from the experimental fishery, seen in the trend in CPUE and biomass estimates from drop frame camera survey, clearly suggest that the imposed experimental harvest rate has been too high for many of the grounds. There are several uncertainties in estimating the abundance and biomass on the scallop grounds. The definition of the grounds was based on the presence of fishing activity by VMS records. The resolution chosen was rather fine or 100*100 m but the complexity of the scallop grounds in Breiðafjörður warren the usage of fine resolution. The initial estimate of fishable grounds was usually a bit too large, compared to what was actually fished. Overestimation of areas led to slightly higher harvest ratio imposed to some region than originally planned. There is also a delay effect as the survey takes place prior to the fishing, but the results from the survey are not available until few months later and the proposed future harvest ratio are most likely higher as the ground has already been fished one season. The abundance estimate has been calculated so far based on length frequency distribution from dredges. The higher ratio of smaller scallops (<60-70mm) seen on all grounds will automatically led to overestimation of the biomass, more pronounced were recruitment is higher. However, the calculations are comparable between years and reflect the changes on the fishing grounds.

In the experimental fishery, harvest rates in areas in the southern part of Breiðafjörður (Breiðasund and Hvammsfjörður) have been rather stable at 6-9%. Recruitment of those substocks has been around average during the experimental period. In the region in northern part of Breiðafjörður, recruitment has been much less pronounced. Abundance and biomass estimates have fallen rather sharply at harvest rate between 6-11% in Bjarneyjar, 8–14% in Flatey and 9-20% in Rúfeyjar. The same trend has been seen in CPUE from the experimental fishing. The stocks in northern areas can be considered recruitment impaired and withstand

little or no fishing. Therefore, it is only proposed to allow fishing in the southern areas, Breiðasund and Hvammsfjörður.

The stock of Iceland scallop in Icelandic waters is considered to be a data limited stock and it is proposed to follow the ICES framework for such stocks (category 3.2) i.e. where survey-based assessments indicate trends the advice is based on the ratio of the mean of the last two biomass indices (Index A) and the mean of the three preceding values (Index B), multiplied by the latest advice (ICES, 2012). That method was applied for Breiðasund and Hvammsfjörður where catch history and survey time series stretch more than 5 years. If the index ratio is estimated to be above 1.2 or below 0.8 an uncertainty cap is applied (applied for both areas), further a precautionary buffer is applied as this method is used for the first time.

Index A / Index B * latest advice

Area Breiðasund TAC: 1.6/2.23 = 0.8 * 0.8 * 97 t = 62 t

Area Hvammsfjörður TAC: 0.663 / 1.17 = 0.8 * 0.8 * 48 t = 31 t

It is recommended that TAC should be issued for each subarea separately, each landing can only come from one subarea, and every tow should be registered in the electronic logbooks.

MFRI advices that when the precautionary approach is applied, catches in the fishing year 2020/2021 should not exceed 93 t in Breiðafjörður; Area: Breiðasund 62 t and Hvammsfjörður 31 t.

Table 1. Iceland scallop. Recommended TAC of Iceland scallop within Breiðafjörður, recommended TAC in Iceland, TAC in Breiðafjörður, catch in Breiðafjörður, total catch in Iceland. Since 1992 the TAC was for following quota year. *Experimental fishery.

Tafla 1. Hörpudiskur. Ráðgjöf fyrir hörpudisk í Breiðafirði, heildarráðgjöf fyrir hörpudisk, aflamark í Breiðafirði, heildaraflamark, afli í Breiðafirði og heildarafli hörpudisks. Síðan 1992 er ráðgjöfin fyrir fiskveiðiárið. *Tilraunaveiðar.

Year	Rec. Breiðafj. TAC	Rec. N. TAC	TAC Breiðafj.	Catch Breiðafj.	Catch Total
1980	-			7100	9100
1981	-			8300	10200
1982	-			10000	12100
1983	-			11200	15200
1984	11000	14100	11000	11900	15600
1985	11000	15400	12000	12100	17100
1986	10000	14200	12000	12700	16400
1987	11000	14500	11000	11000	13300
1988	10000	13500	10000	9800	10100
1989	9000	12500	10000	10100	10800
1990	10000	13500	10000	10100	12400
1991	9000	12500	9000	8900	10300
1992	8500	11200	8500	10600	12400
1992/93	8500	11500	8500	10300	11600
1993/94	8000	10100	9800	8000	9400
1994/95	8500	10200	8200	8800	9400
1995/96	8000	9500	8000	7400	8000
1996/97	8000	9300	8000	8400	9200
1997/98	8000	9300	8000	8900	10600
1998/99	8500	9800	8500	8100	9100
1999/00	8500	9800	8500	8700	9200
2000/01	8000	9300	8000	7900	8200
2001/02	6500	6750	6500	6400	6600
2002/03	4000	4150	4000	4435	4505
2003/04	0	0	0	0	0
2004/05	0	0	0	0	0
2005/06	0	0	0	0	0
2006/07	0	0	0	0	0
2007/08	0	0	0	0	0
2008/09	0	0	0	0	0
2009/10	0	0	0	0	0
2010/11	0	0	0	0	0
2011/12	0	0	0	0	0
2012/13	0	0	0	0	0
2013/14	0	0	0	15	15
2014/15	*	-	-	266	266
2015/16	*	-	-	635	635
2016/17	*	-	-	590	590
2017/18	*	-	-	942	944
2018/19	*	-	-	694	697
2019/20	*	-	-	451	
2020/21	93				

Table 2. Iceland scallop. A scheme for experimental fishery in Breiðafjörður by areas. The starting proposal and the catch of each area during the following winter.

Tafla 2. Hörpudiskur. Tillögur fyrir tilraunaveiðar hvers veturs í Breiðafirði eftir svæðum og veiði.

Area	Prop. 2019	Catch 2019	Prop. 2018	Catch 2018	Prop. 2017	Catch 2017
Hvammsfjörður	48	49	88	89	100	104
Breiðasund	97	101	97	97	140	143
Skálmarnes	20	0	53	7	150	45
Látralönd	30	0	143	11	190	185
Flatey	99	103	296	204	250	272
Bjarneyjar	128	121	205	208	200	198
Rúfeyjar	77	78	77	78	-	-
Total	499	452	959	694	1030	945

Table 3. Iceland scallop. Breiðasund. Number of scallops per m^2 with standard error, mean shell height (mm) in dredges, ratio of scallops above 60 mm, catch in the area and harvest ratio. The size of fishable area in Breiðasund was estimated 5,64 km^2.

***Tafla 3. Hörpudiskur. Breiðasund. Fjöldi skelja á fermeter með staðalskekkju, meðal skel hæð (mm) í plóg, hlutfall skelja yfir 60 mm, afli og veiðihlutfall.* Stærð veiðisvæðis í Breiðasundi var metið vera 5,64 km^2.**

Year	Mean N	Mean SH	Ratio < 60mm	Biomass	Catch	HR
2014 May	8.86 (±1.01)	76.1	3.8%	3000	281	9,0%
2014 Nov	6.24 (±0.76)			2112		
2015	-				116	
2016	-				42	
2017	5.76 (±1.28)	71.1	6.4%	1591	143	9,0%
2018	6.64 (±1.48)	70.0	11.9%	1745	97	5,6%
2019	5.31 (±0.78)	71.5	7.8%	1468	101	6,9%

Table 4. Iceland scallop. Hvammsfjörður. Number of scallops per m^2 with standard error, mean shell height (mm) in dredges, ratio of scallops above 60 mm, catch in the area and harvest ratio. The size of fishable area in Hvammsfjörður was estimated 2,34 km^2.

***Tafla 4. Hörpudiskur. Hvammsfjörður. Fjöldi skelja á fermeter með staðalskekkju, meðal skel hæð (mm) í plóg, hlutfall skelja yfir 60 mm, afli og veiðihlutfall.* Stærð veiðisvæðis í Hvammsfirði var metið vera 2,34 km^2.**

Year	Mean N	Mean SH	Ratio < 60mm	Biomass	Catch	HR
2014	10.49 (±3.17)	67.1	16.3%	990		
2015	-	-	-		116	10.7%
2016	-	-	-		85	
2017	13.32 (±3.24)	68.6	14.3%	1341	104	7,8%
2018	5.07 (±1.02)	68.4	9.1%	504	89	17,7%
2019	7.22 (±2.50)	71.2	3.6%	822	49	6,0%

Table 5. Iceland scallop. Flatey. Number of scallops per m² with standard error, mean shell height (mm) in dredges, ratio of scallops above 60 mm, catch in the area and harvest ratio. The size of fishable area in Flatey was estimated 3.83 km².

Tafla 5. Hörpudiskur. Flatey. Fjöldi skelja á fermeter með staðalskekkju, meðal skel hæð (mm) í plóg, hlutfall skelja yfir 60 mm, afli og veiðihlutfall. **Stærð veiðisvæðis vestura af Flatey var metið vera 3,83 km².**

Year	Mean N	Mean SH	Ratio < 60mm	Biomass	Catch	HR
2016	14.62 (±2.1)	75.5	7.3%	3349	260	7.8%
2017	9.31 (±1.6)	76.7	2.6%	2216	272	12,3%
2018	6.64 (±0.6)	76.4	5.0%	1453	204	14,0%
2019	5.31 (±0.5)	78.1	2.1%	1134	103	9,1%

Table 6. Iceland scallop. Bjarneyjar. Number of scallops per m² with standard error, mean shell height (mm) in dredges, ratio of scallops above 60 mm, catch in the area and harvest ratio. The size of fishable area in Bjarneyjar was estimated 3,26 km².

Tafla 6. Hörpudiskur. Bjarneyjar. Fjöldi skelja á fermeter með staðalskekkju, meðal skel hæð (mm) í plóg, hlutfall skelja yfir 60 mm, afli og veiðihlutfall. **Stærð veiðisvæðis við Bjarneyjar var metið vera 3,26 km².**

Year	Mean N	Mean SH	Ratio < 60mm	Biomass	Catch	HR
2016	15.02 (±2.8)	77.4	1.4%	3090	-	-
2017	-	-	-	-	198	6,4%
2018	8.64 (±1.19)	78.6	2.4%	1875	208	11,1%
2019	5.84 (±0.54)	78.1	1.7%	1242	121	9,7%

Table 7. Iceland scallop. Rúfeyjar. Number of scallops per m² with standard error, mean shell height (mm) in dredges, ratio of scallops above 60 mm, catch in the area and harvest ratio. The size of fishable area in Rúfeyjar was estimated 1,05 km².

Tafla 7. Hörpudiskur. Rúfeyjar. Fjöldi skelja á fermeter með staðalskekkju, meðal skel hæð (mm) í plóg, hlutfall skelja yfir 60 mm, afli og veiðihlutfall. **Stærð veiðisvæðis Við Rúfeyjar var metið vera 1,05 km².**

Year	Mean N	Mean SH	Ratio < 60mm	Biomass	Catch	HR
2017	18.24 (±4.4)	75.4	1.0%	1114	-	-
2018	12.94 (±2.3)	77.1	0.4%	850	78	9,2%
2019	5.75 (±0.95)	77.2	1.0%	378	78	20,6%

Table 8. Iceland scallop. Látralönd. Number of scallops per m² with standard error, mean shell height (mm) in dredges, ratio of scallops above 60 mm, catch in the area and harvest ratio. The size of fishable area in Látralönd was estimated 4,09 km².

Tafla 8. Hörpudiskur. Látralönd. Fjöldi skelja á fermeter með staðalskekkju, meðal skel hæð (mm) í plóg, hlutfall skelja yfir 60 mm, afli og veiðihlutfall. **Stærð veiðisvæðis við Látralönd var metið vera 4.09 km².**

Year	Mean N	Mean SH	Ratio < 60mm	Biomass	Catch	HR
2015	8.92 (±0.93)	75.6	4.4%	2155	264	12,3%
2016	7.71 (±1.36)	73.5	9.0%	1677	138	8,2%
2017	5.97 (±0.79)	72.1	8.1%	1237	183	14,8%
2018	3.84 (±0.54)	73.7	5.3%	869	11	1,3%
2019	3.70 (±0.42)	73.9	5.6%	843	0	-

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