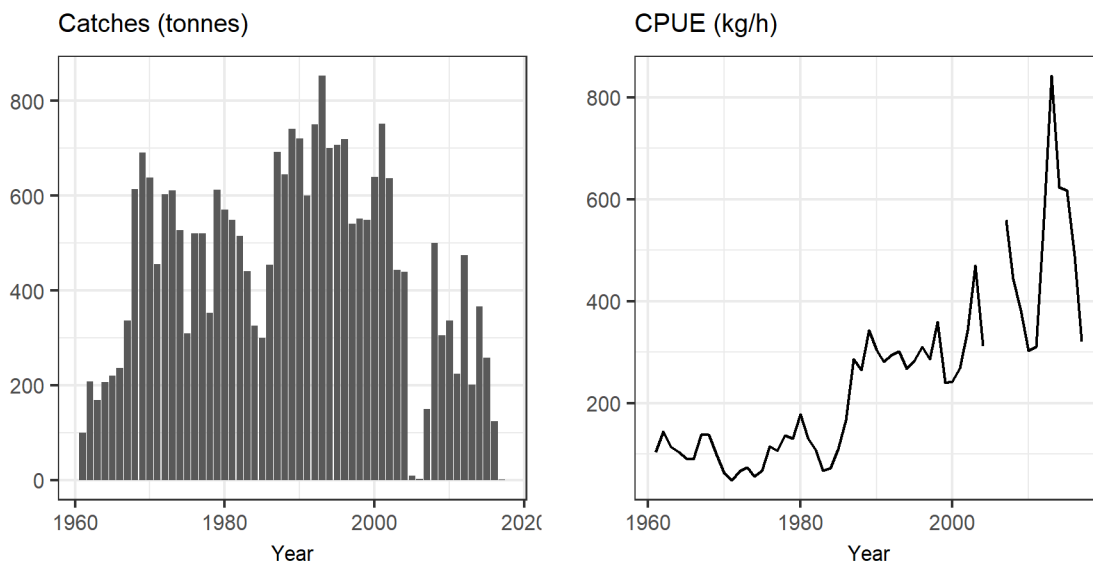


# SHRIMP IN ARNARFJÖRÐUR – RÆKJA Í ARNARFIRÐI

## *Pandalus borealis*

### THE FISHERY

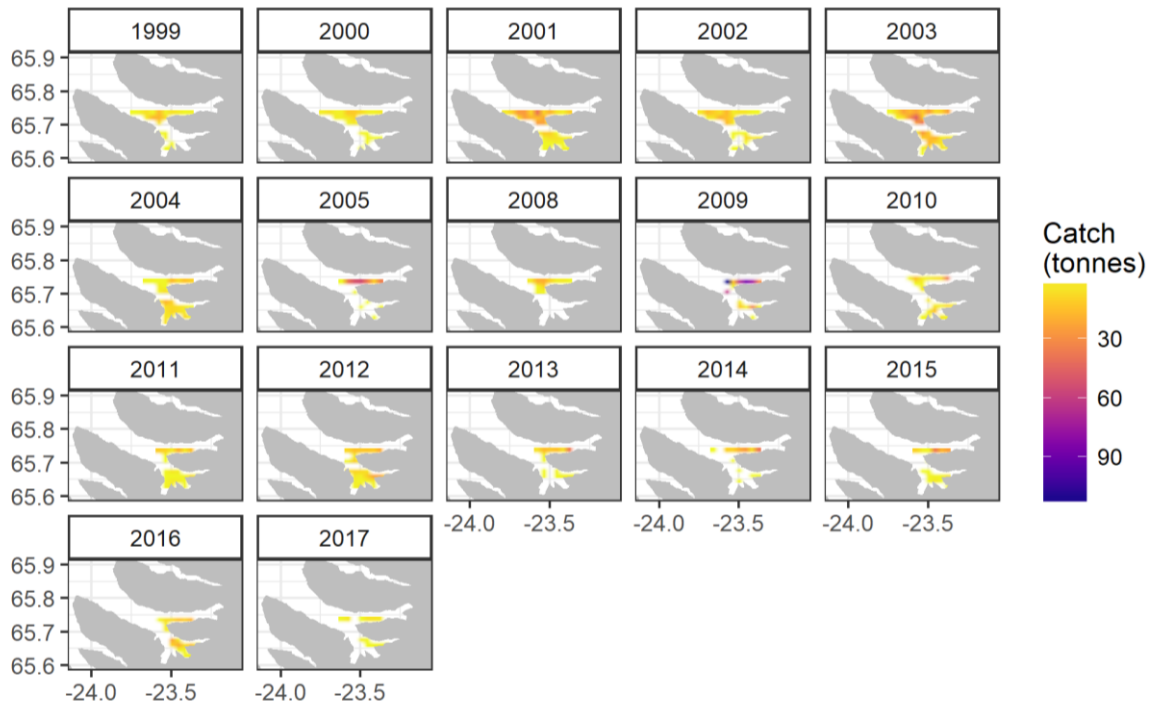
Shrimp fishing started in Arnarfjörður in the 1930's. Between 1960 and 2015, the catch in Arnarfjörður fluctuated between 100 and 850 tonnes, except in the quota years 2005/2006 and 2006/2007 (Figure 1) when no fishing was allowed due to low shrimp biomass in the area. Since 1994, the catch has decreased 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. 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.**

*Mynd 1. Rækja í Arnarfirði. Heildarafli og afli á sóknareiningu.*

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.



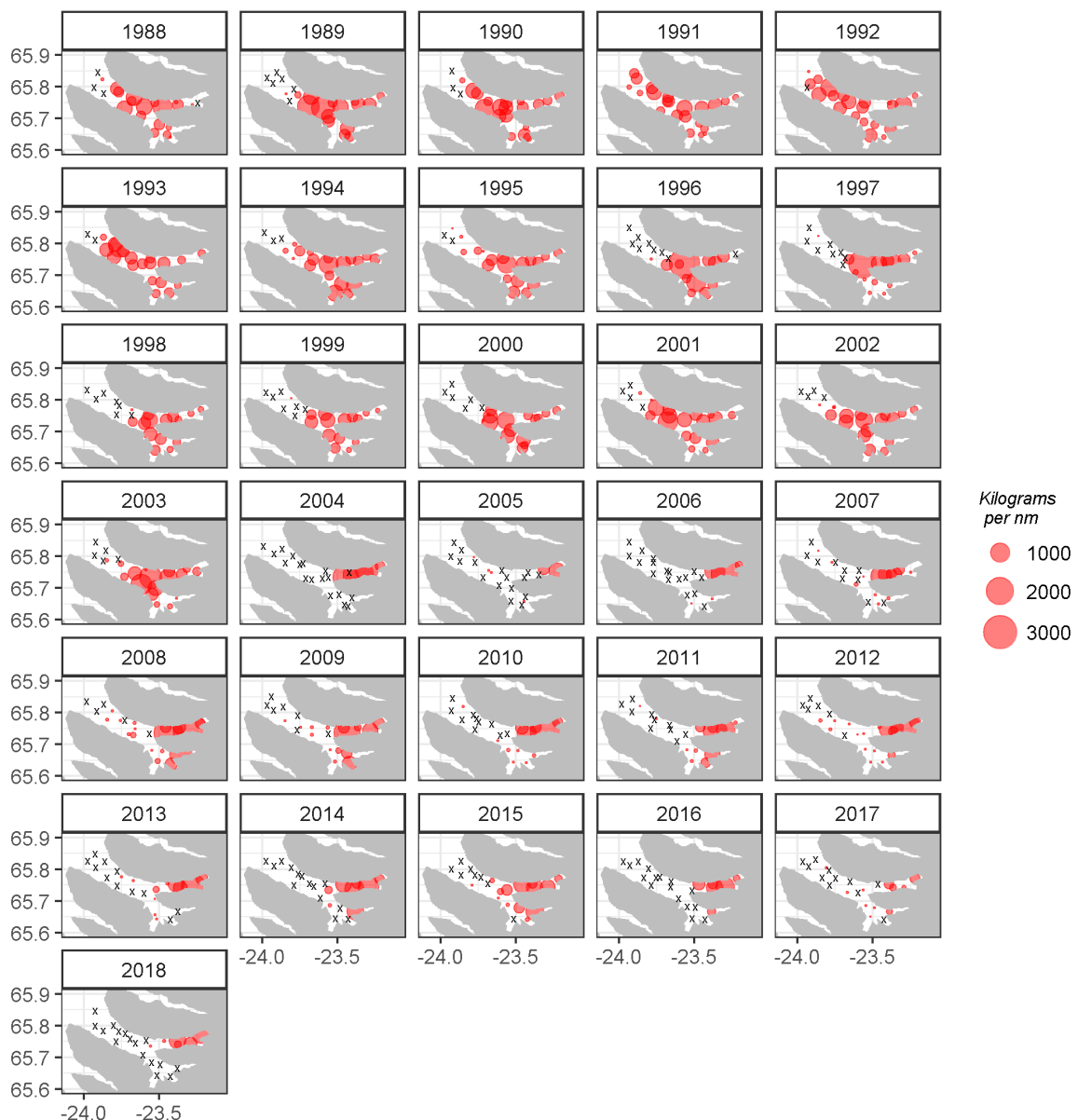
**Figure 2. Shrimp in Arnarfjörður. Distribution of shrimp catch in Arnarfjörður.**

*Mynd 2. Rækja í Arnarfirði. Dreifing rækjuafla í Arnarfirði.*

## SURVEY DATA

The annual Icelandic shrimp survey has been conducted since 1988 in Arnarfjörður. The 2018 survey was conducted on 6-10 October and included 22 fixed stations at depths of 49-95 m. Information on sampling procedure can be found in the report 'Northern shrimp research in Icelandic waters, 1988–2015' (Jónsdóttir et al. 2017).

In 1988–1996, shrimp was found throughout the whole fjord (Figure 3). 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 2018 northern shrimp was only found in the northern arm of the inner most part of the fjord.



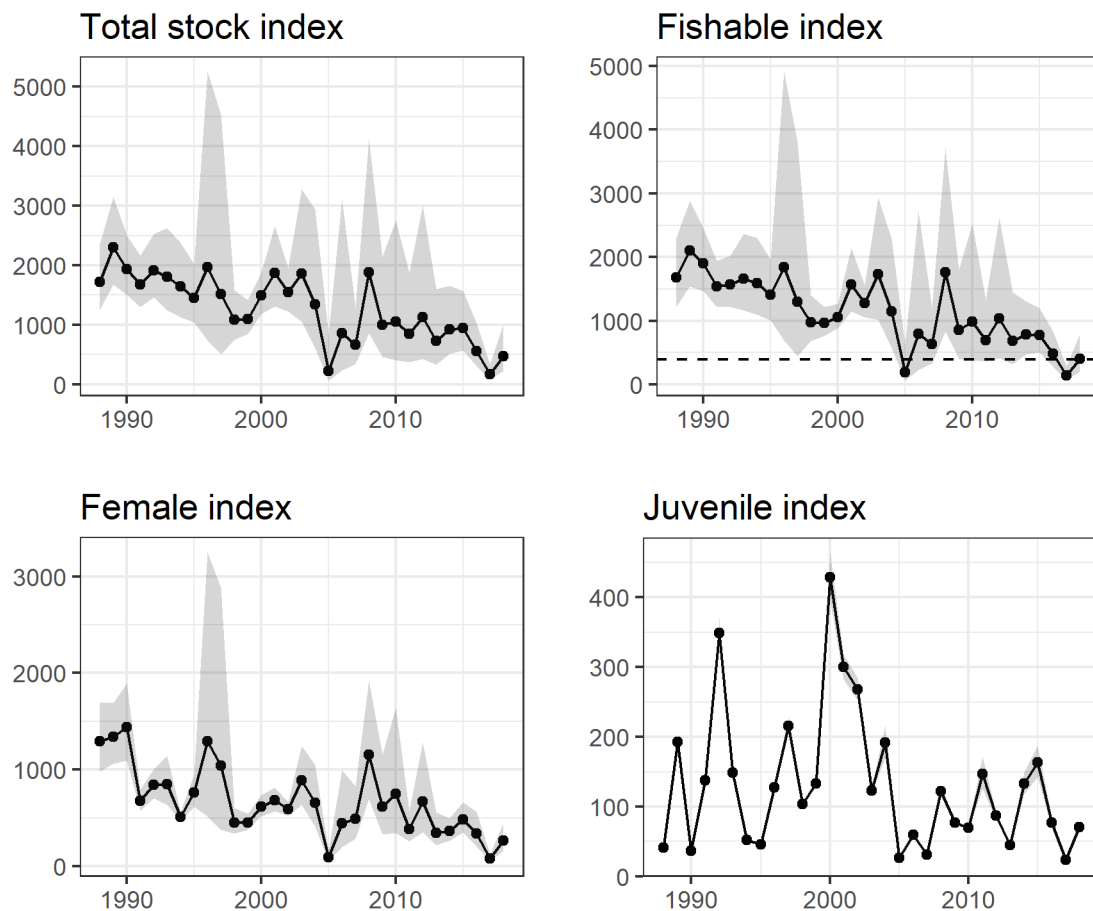
**Figure 3. Shrimp in Arnarfjörður. Distribution and abundance of shrimp in the annual shrimp survey. X denotes stations where no northern shrimp was found.**

*Mynd 3. Rækja í Arnarfirði. Útbreiðsla og magn rækju í stofnmælingu. x sýnir stöðvar þar sem engin rækja fékkst.*

## 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 4). 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. In 2017 the fishable index was at historically low levels and below the reference level. In 2018, the fishable biomass index was just above the reference level.

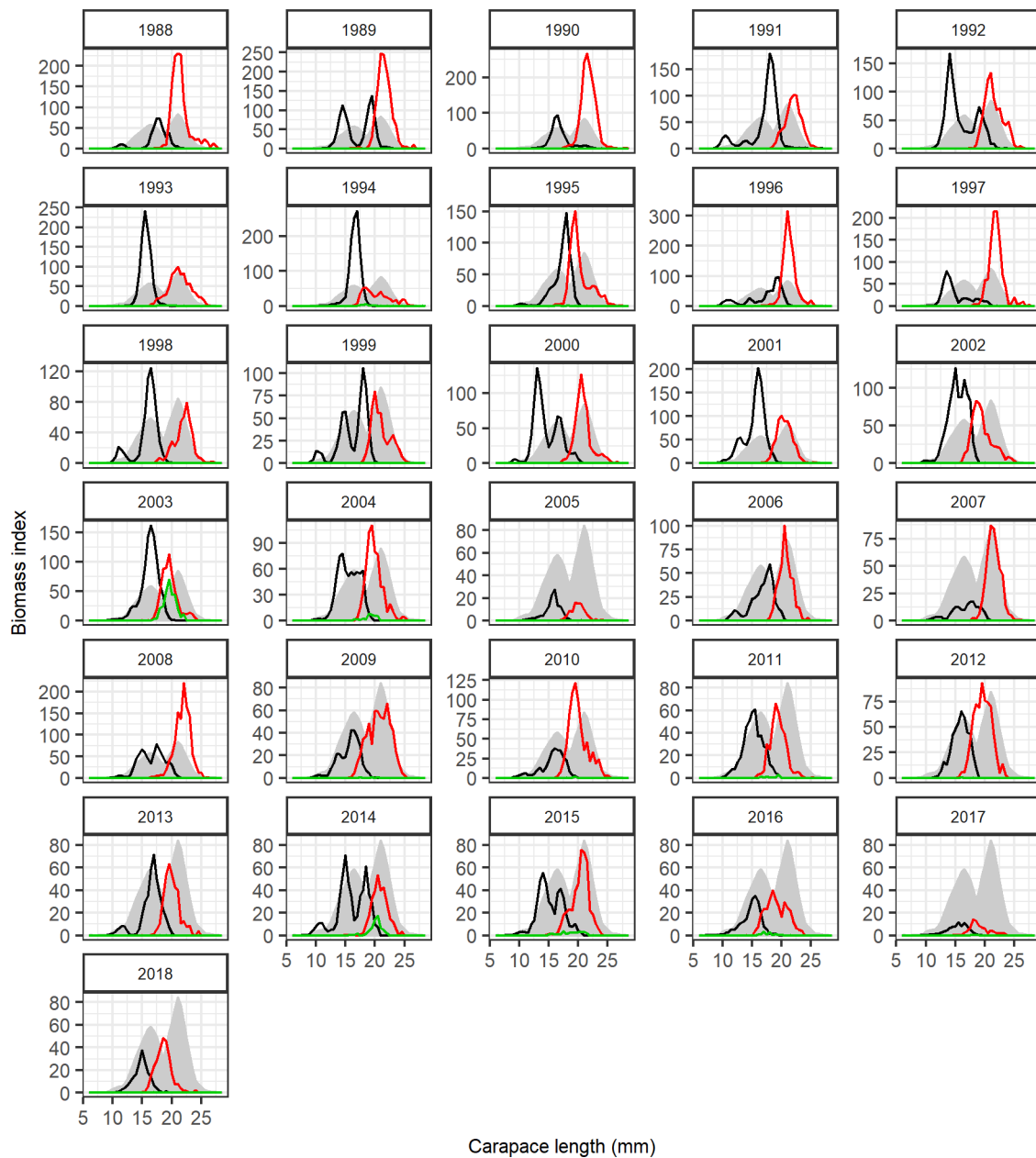


**Figure 4.** Shrimp in Arnarfjörður. Stock biomass index, fishable biomass index, female biomass index and juvenile biomass index of shrimp. The horizontal line indicates a value where the state of the stock is considered to be critical (20% of the mean of the three highest indices).

*Mynd 4. Rækja í Arnarfirði. Heildarstofnsvísitala, veiðistofnsvísitala, kvendýravísitala og vísitala ungrækju. Lárétt lína sýnir viðmiðunargildi fyrir ástand stofnsins (20% af meðaltali þriggja hæstu vísitalna).*

## LENGTH DISTRIBUTION

Since 2011, females have been smaller than average and have not reached the same maximum size as before (Figure 5). In 2018, the shrimp stock in Arnarfjörður was dominated by only two age groups.



**Figure 5. Shrimp in Arnarfjörður. Length distribution. The black line indicates males, the green immature females, and the red line mature females. The grey area is the mean length distribution of both sexes for the whole study period. Note different scales on y-axes.**

*Mynd 5. Rækja í Arnarfirði. Lengdardreifing rækju. Svört lína sýnir karldýr, græn lína ókynþroska kvendýr og sú rauða kynþroska kvendýr. Gráa svæðið sýnir meðallengdardreifingu beggja kynja allt rannsóknatímabilið. Athugið mismunandi skala á y-ás.*

## ABUNDANCE OF COD AND HADDOCK

In general, the cod abundance index has fluctuated throughout the study period. The cod abundance index has been decreasing since 2014. The haddock abundance index increased from 1994 to 2008 but decreased until 2014 (Figure 6). In 2018, the abundance of haddock was higher compared to the past four years. Few 0-group cod and haddock were observed in Arnarfjörður in 2018.

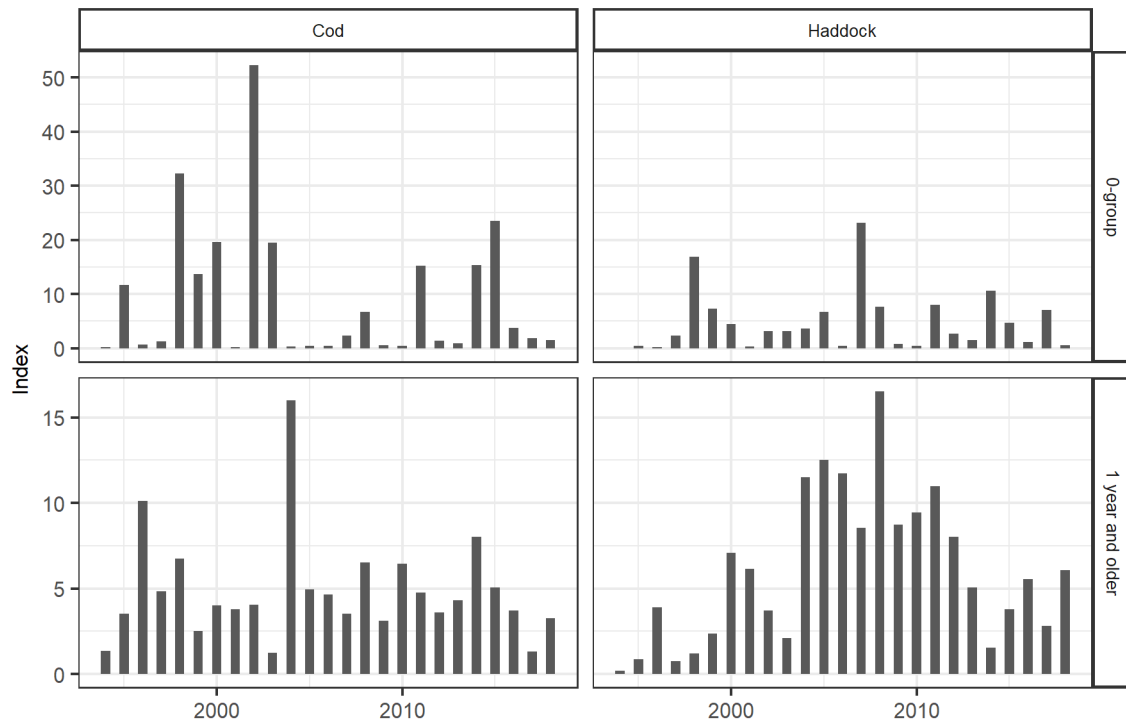


Figure 6. Cod and haddock in Arnarfjörður. Abundance indices of cod and haddock in the annual shrimp survey.

*Mynd 6. Þorskur og ýsa í Arnarfirði. Vísitala þorsks og ýsu í stofnmælingu rækju.*

## MANAGEMENT

The Ministry of Industries and Innovation is responsible for management of all marine fisheries in Iceland and implementation of legislation. The fishing season is from early winter (following the annual Icelandic shrimp survey in September/October) until 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  $F_{\text{proxy}}$ .**

*Tafla 1. Rækja í Arnarfirði. Heildarstofnsvísitala, ástand stofns (vísitala miðað við meðaltal þriggja hæstu vísitölugilda), ráðgjöf, afli og vísitala veiðihlutfalls ( $F_{\text{proxy}}$ ).*

Year	Biomass index	Relative state	Rec. TAC	National TAC	Catch	$F_{\text{proxy}}$
<b>1988/89</b>	1683	0.86				
<b>1989/90</b>	2107	1.08				
<b>1990/91</b>	1902	0.97	700	700	720	0.38
<b>1991/92</b>	1536	0.79	600	600	605	0.39
<b>1992/93</b>	1569	0.80	750	750	751	0.48
<b>1993/94</b>	1660	0.85	850	850	853	0.51
<b>1994/95</b>	1588	0.81	700	700	699	0.44
<b>1995/96</b>	1406	0.72	700	700	708	0.50
<b>1996/97</b>	1843	0.94	700	700	720	0.39
<b>1997/98</b>	1296	0.66	550	550	546	0.42
<b>1998/99</b>	982	0.50	550	550	551	0.56
<b>1999/00</b>	965	0.49	550	550	548	0.57
<b>2000/01</b>	1060	0.54	650	650	639	0.60
<b>2001/02</b>	1569	0.80	750	750	752	0.48
<b>2002/03</b>	1281	0.66	650	650	637	0.50
<b>2003/04</b>	1733	0.89	750	750	748	0.43
<b>2004/05</b>	1149	0.59	450	450	440	0.38
<b>2005/06</b>	195	0.10	0	0	9	-
<b>2006/07</b>	793	0.41	0	0	3	-
<b>2007/08</b>	632	0.32	150	150	158	0.25
<b>2008/09</b>	1762	0.90	500	500	508	0.29
<b>2009/10</b>	857	0.44	300	300	314	0.37
<b>2010/11</b>	984	0.50	400	400	337	0.34
<b>2011/12</b>	697	0.36	200	200	224	0.32
<b>2012/13</b>	1040	0.53	450	450	475	0.46
<b>2013/14</b>	687	0.35	200	200	201	0.29
<b>2014/15</b>	786	0.40	350	350	366	0.47
<b>2015/16</b>	779	0.40	250	250	258	0.33
<b>2016/17</b>	484	0.25	167	167	124	0.26
<b>2017/18</b>	140	0.07	0	0	1	-
<b>2018/19</b>	402	0.21	139			

## ADVICE 2018

The Icelandic shrimp survey was used as a biomass indicator. The target  $F_{\text{proxy}}$  (catch/survey biomass) of 0.346 is considered precautionary based on the historical relationship between catch and survey index.

The state of the stock is considered critical if the total biomass index is below 390 (equivalent to a relative state of 0.2; the biomass index divided with the mean of the three highest indices). The biomass index value of 390 can therefore be considered a proxy for  $B_{\text{lim}}$  or  $I_{\text{lim}}$ . If the total biomass index is below 390, zero catch is advised, else the advice is based on multiplying the most recent index with the target  $F_{\text{proxy}} = 0.346$ .

In October 2018, the total biomass index was 402. Hence, MFRI advises that catch in Arnarfjörður should be no more than 139 tonnes in the quota year 2018/2019.