



Serial No. N7015

NAFO SCR Doc. 19/051

**NAFO/ICES PANDALUS ASSESSMENT GROUP MEETING – November 2019**

**Assessment of the International Fishery for Shrimp (*Pandalus borealis*)  
in Division 3M (Flemish Cap), 1993-2019**

by

J. M. Casas

Instituto Español de Oceanografía, Apdo. 1552, 36200 Vigo, Spain

e-mail: [mikel.casas@vi.ieo.es](mailto:mikel.casas@vi.ieo.es)

**Abstract**

This paper describes the development of the international shrimp (*Pandalus borealis*) fishery in NAFO Division 3M. Various indices show that even though the stock was in high levels, in 2006 and 2007 the lack of good recruitments in the last thirteen years and the progressive disappearance of the strong year classes 2001 and 2002 caused a drastic decline of the stock. Although since 2011 a moratorium over shrimp fishery was established, predation by redfish and cod contributed to the decline of shrimp especially after 2007-2008. The increment of large specimens in the cod stock, especially since 2010, increased the predation mortality on redfish, inducing the decrease of the redfish stock and as consequence the decline of the predation mortality on shrimp favouring the increase of shrimp stock in the last years. The last assessment (biannual) for this resource was completed, within Scientific Council during autumn 2017. Scientific Council recommended that the fishing mortality for 2018 and 2019 be set as close to zero as possible.

The indices of biomass in the 2019 EU survey increase, confirming recent upward trend. The stock size is now well above  $B_{lim}$  and it is from 2018 outside the collapse zone defined by the NAFO PA framework. In 2019 the total and female biomass indices were 9273 and 8486 t respectively. The abundance at age 2 was similar to the estimated in 2018 but although recruitment has been weak in the last decade, the recruitment index (age 2) has been increasing since the lowest observed in 2014. Also in 2019 the year-class corresponding to the 2018 cohort (pre-recruits) was stronger than in recent years, but it is unclear how this will impact future dynamics.

Scientific Council considers that there is sufficient evidence to allow a small amount of directed fishing on this stock. Considering the uncertainty about the future recruitments and the response of the resource to resumed exploitation, Scientific Council advises that the level exploitation in 2020 should not exceed the 25% of 2009 levels (2 640 days).

## 1. INTRODUCTION

The fishery for northern shrimp at Flemish Cap began in the spring of 1993 and has since continued with estimated annual catches (as estimated by STACFIS, Table 1) of approximately 26 000 t to 48 000 t in the years 1993 through 1996. After 1996 the catches were lower and rising slowly from 26 000 t in 1997 to 53 000 t in 2000 and 2001. There was 50 000 t taken in 2002. The catch increased in 2003, reaching the highest value in



the catches series (64 000 t). After 2003 the catches decreased all years until 1 988 t in 2010. Due to the moratorium initiated in 2011, no catches have been recorded since then, and by 2019 only very low catches of discards from other fisheries are expected.

Since 1993 the number of vessels ranged from 40-110, and in 2006 there were approximately 20 vessels fishing shrimp in Div. 3M compared to 50 in 2004. There is not a lot of information on the number of vessels taking part in the shrimp fishery since 2007 but probably they do not exceeded 13 units in 2010. Since 2011 due to the moratorium there is no vessels directed to shrimp fishery in Div. 3M.

With the closure of the international shrimp (*Pandalus borealis*) fishery in NAFO Division 3M, various indices from the EU surveys are listed to assess the status of the Flemish Cap shrimp stock. Among these the indices of female stock from the EU surveys is used. The results from the ageing are presented and some recruitment indices from the EU survey are provided.

## 2. MATERIAL AND METHODS

### *Samples*

From 2011 due to the moratorium shrimp samples were only taken from EU-Flemish Cap research summer surveys. They were separated into 3 categories namely, males, primiparous females (including transitional) and multiparous females according to the sternal spine criterion (McCrary. 1971), oblique carapace lengths were measured using sliding callipers and grouped into 0.5 mm length-classes.

Modal analysis (MacDonald and Pitcher, 1979) was conducted each year on length frequency distribution by sex group resulting from the survey. This analysis provided the proportion; mean lengths and standard deviations of the mean length ( $\sigma$ ) for each age component and sex group. The total number of individuals in every age/sex group according to the estimated biomass was calculated transforming the mean length to weight using the weight length relationship. So, the mean lengths were converted to mean weights to estimate the annual abundance and biomass indices by year and sex group (Skúladóttir and Diaz, 2001).

## 3. CATCH and CPUE

The total catch per year is listed by nations in Table 1. The annual catches come mostly from Statlant 21A reports and in some cases from the shrimp specialists of individual countries. Because the moratorium no catches have been recorded from 2011 and to 10 September in 2019 the table was only revised and updated (Fig. 1).

The closure of shrimp fishery from 2011 and therefore the lack of commercial catches of shrimp do not permit to follow the evolution of the stock using the standardized CPUE series estimated from the international fleet directed to the fishing shrimp in Div. 3M.

## 4. EXPLOITATION RATE

Considering the Exploitation rate estimated as nominal catches divided by the EU survey biomass index of the same year (Figure 2 and Table 2), this was high in the years 1994-1997 when biomass was generally lower. In the years 1998-2004 the catch rate has been rather stable at a lower level. From 2005 to 2008 despite the exploitation rate remained stable at relative low values (between 1.9-1.5), the UE survey indexes estimated decreased year after year. This trend continued in the following years until 2015 despite the moratorium established on 3M shrimp stock since 2011. In October 2011 Scientific Council noted that there are indications of factors other than fishery that may be involved in the current decline of the stock.

## 5. FEMALE INDICES

The biomass indices from EU surveys have been corrected in the years 1988 to 2002 for adjusting for the more efficient research vessel taken into use in 2003 (Casas *et al.* 2004). The spawning stock (female biomass)

as determined from the EU survey biomass index (Figure 3 and Table 3) increased rapidly during the years prior to the fishery, from 1989 and 1990 to 1992. This may have been due to a gradual increase in stock size after the cod biomass declined in the area. But this was also a reflection of the very strong 1986 year class, most of which were female during 1992. With the beginning of the shrimp fishery in 1993 the biomass declined up to 1997. After that the stock recovered reasonably well although with high annual variability (historical maximums in 2002 and 2005 were followed by years with lower biomass but at a relative high level). In 2009 the female biomass decreased to values close to the historical minimums in the survey series. In 2010 despite of the biomass increase about 77% compared to 2009 this was still among the lowest in the historical series. The female biomass estimated from the moratorium (2011-2014) were the lowest values in the EU survey series, well below  $B_{lim}$  proxy and showed the depletion state of the shrimp stock that years. Since 2015 the biomass indexes increased year after year and they are now above  $B_{lim}$  (Figure 3).

## 6. SHRIMP PREDATION BY COD AND REDFISH

Studies based in multispecies model developed in Gadget which covers the main commercial stocks in Flemish Cap over the period 1988-2012. (Pérez-Rodríguez et al. 2016) and 1988-2016 (Pérez-Rodríguez and D. González-Troncoso 2018), suggest that, predation by redfish, together with fishing have been the main factors driving the shrimp stock to the collapse (Table 3 and Figure 4). Predation by cod contributed to the decline of shrimp especially after 2007-2008. Also, the increment of large cod in the stock, especially since 2010, has raised the predation mortality on redfish, inducing the decline of redfish stock in the last years, the decreasing of the predation mortality on shrimp and as consequence favouring its recovery.

## 7. AGE ASSESSMENTS

Age analysis and sex composition was carried out on biological samples obtained from commercial fishery of a few nations in the past years (1993-2005). Since 2006 the samples obtained from the fishery were insufficient to assess the age of the catches and from 2011 due to the moratorium no sampling is available. So, the perception of the age composition and evolution of different year class along the years in the shrimp stock come from the age composition estimated in EU surveys (tables 4 and 5).

From those tables, some strong year-classes may be followed according the abundance by age groups from EU surveys (1988-2006). If the assignation of the age is right, the 1986 year-class stand out in the beginning of historical series with 4, 5 and 6 years olds in the years 1990, 1991 and 1992. The individuals with 4 year olds were also especially abundant in the years 1999-2002 indicating the strong of year-classes 1995, 1996, 1997 and 1998. The 1999 year-class stand out especially judging by the high number of 3 and 6 year olds in 2002 and 2005 years respectively. In these two years both the biomass and the abundance reached out the highest values in the series, especially in 2005 where the strong 2002 year class with 3 years old was also present. From 2004 to present the virtual absence of age group 1 in the catches and very low values for the ages 2 and 3 show the weakness of the 2003 -2017 year classes.

## 8. RECRUITMENT

Considering the abundance at age 2 as indicator of recruitment, the EU survey provided two recruitment indices. The abundance of two years olds obtained in the main trawl since 1996 and the abundance for this age group in the juvenile shrimp bag attached to the main gear since 2001. Both are presented together in table 6 and Figure 5.

Since 2005, the survey indices from Lofoten gear showed high variability in the estimated values but lower than in previous years, and confirming the absence of strong year classes. A similar trend can be observed from juvenile bag's indexes. In 2018 and 2019 these indexes increased but remain low and confirm the weakness of the 2017 year class. In 2019 the year-class corresponding to the 2018 cohort (pre-recruits; not shown) was stronger than in recent years, but it is unclear how this will impact future dynamics.

## 9. PRECAUTIONARY APPROACH

In the absence of other suitable methods to indicate a limit reference point for biomass, the EU survey biomass female index was used (SCS Doc. 04/12). Scientific Council considers that a female survey biomass index of 15% of its maximum observed level provides a proxy for  $B_{lim}$ . This corresponds to an index value of 2 564 t (Figure 6).

A limit reference point for fishing mortality has not been defined.

## 10. SUMMARY

Catches of shrimp on the Flemish Cap have been maintained at a high level averaging 43 000 t. between 1995 and 2005. However since 2006 they decreased gradually being in 2010 around 1990 t. No catches have been reported since 2011 as consequence of the moratorium of this fishery.

After some years with exploitation rates stables at relative low values (1.9-1.5 from 2005 to 2008) the UE survey indexes estimated showed a decreasing trend until 2014 despite the moratorium established on 3M shrimp stock from 2011.

The female biomass index from the EU survey decreased between 1993 and 1994, increased from 1997 to 1998 and stayed stable to 2007. In 2008 and 2009 declined abruptly and from 2011 to 2014 decreased successively recording the lowest values in the historical series and falling below  $B_{lim}$ . Since 2015 the biomass index showed an upward trend and considering the 15% of the maximum survey female biomass index as a limit reference point for biomass ( $B_{lim}$ ), the stock is now well above  $B_{lim}$ .

Although recruitment has been weak in the last decade, the recruitment index (age 2) has been increasing since the lowest observed in 2014.

In the most recent years, decreasing redfish and cod stocks have likely resulted in reduced predation mortality on shrimp, consistent with a period of increase in the shrimp stock.

Scientific Council notes the improvement of the stock after 5 years with continuous increase of biomass it now has a very probability on being bellow  $B_{lim}$ . and that there is sufficient evidence to allow a small amount of directed fishing on this stock. Considering the uncertainty about the future recruitments and the response of the resource to resumed exploitation, Scientific Council advises that the level exploitation in 2020 should not exceed the 25% of 2009 levels (2640 days).

## 11. ACKNOWLEDGEMENT

Appreciation is expressed to those who provided data for inclusion in this paper. Most of data used in this paper have been funded by the EU through the European Maritime and Fisheries Fund (EMFF) within the National Program of collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy.

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**Table 1.** Annual nominal catches (t) by country of northern shrimp (*Pandalus borealis*) caught in NAFO Div. 3M.

| Nation            | 1993              | 1994              | 1995              | 1996               | 1997              | 1998              | 1999               | 2000               | 2001               | 2002               | 2003               | 2004               | 2005               | 2006              | 2007               | 2008               | 2009              | 2010             | 2011* | 2012* | 2013* | 2014* | 2015* | 2016* | 2017* | 2018* | 2019* |                |  |
|-------------------|-------------------|-------------------|-------------------|--------------------|-------------------|-------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|-------------------|--------------------|--------------------|-------------------|------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|----------------|--|
| Canada            | 3724              | 1041              | 970               | 906                | 807               | 484               | 490 <sup>2</sup>   | 618 <sup>2</sup>   | 295 <sup>1</sup>   | 16                 |                    |                    |                    | 10 <sup>1</sup>   |                    |                    |                   |                  |       |       |       |       |       |       |       |       |       |                |  |
| Cuba              |                   |                   |                   |                    |                   |                   | 119                | 46 <sup>1</sup>    | 1037 <sup>1</sup>  | 1537 <sup>1</sup>  | 1462 <sup>1</sup>  | 969 <sup>1</sup>   | 964 <sup>1</sup>   | 1126 <sup>1</sup> | 446 <sup>1</sup>   | 11                 |                   |                  |       |       |       |       |       |       |       |       |       |                |  |
| EU/Estonia        |                   | 1081              | 2092              | 1900               | 3240              | 5694              | 10835 <sup>1</sup> | 13256 <sup>2</sup> | 9851 <sup>1</sup>  | 14215 <sup>2</sup> | 12851 <sup>1</sup> | 13444 <sup>1</sup> | 12009 <sup>1</sup> | 8466 <sup>2</sup> | 10607 <sup>2</sup> | 10255 <sup>2</sup> | 2152 <sup>2</sup> | 266 <sup>2</sup> |       |       |       |       |       |       |       |       |       |                |  |
| EU/Denmark        | 800               | 400               | 200               |                    |                   | 437               | 235                |                    | 93 <sup>1</sup>    | 359 <sup>1</sup>   |                    |                    |                    |                   |                    |                    |                   |                  |       |       |       |       |       |       |       |       |       |                |  |
| EU/Latvia         |                   | 300               | 350               | 1940               | 997 <sup>1</sup>  | 1191 <sup>1</sup> | 3080 <sup>1</sup>  | 3105 <sup>1</sup>  | 2961 <sup>1</sup>  | 1892 <sup>1</sup>  | 3533 <sup>1</sup>  | 3059 <sup>1</sup>  | 2212 <sup>1</sup>  | 1330 <sup>1</sup> | 1939 <sup>1</sup>  | 1285 <sup>1</sup>  | 1194 <sup>1</sup> | 611 <sup>1</sup> |       |       |       |       |       |       |       |       |       |                |  |
| EU/Lithuania      |                   | 1225              | 675               | 2900               | 1785 <sup>1</sup> | 3107 <sup>1</sup> | 3370 <sup>1</sup>  | 3529 <sup>1</sup>  | 2701 <sup>1</sup>  | 3321 <sup>1</sup>  | 3744 <sup>1</sup>  | 4802 <sup>1</sup>  | 3652 <sup>1</sup>  | 1245 <sup>1</sup> | 1992 <sup>1</sup>  | 485 <sup>1</sup>   |                   | 102 <sup>1</sup> |       |       |       |       |       |       |       |       |       |                |  |
| EU/Poland         |                   |                   |                   |                    | 824               | 148 <sup>1</sup>  | 894 <sup>1</sup>   | 1692 <sup>1</sup>  | 209 <sup>1</sup>   |                    |                    | 1158 <sup>1</sup>  | 458 <sup>1</sup>   | 224 <sup>1</sup>  |                    |                    |                   |                  |       |       |       |       |       |       |       |       |       |                |  |
| EU/Portugal       | 300               |                   | 150               |                    | 170 <sup>1</sup>  | 203 <sup>1</sup>  | 227 <sup>1</sup>   | 289 <sup>1</sup>   | 420 <sup>1</sup>   | 16 <sup>1</sup>    |                    | 50 <sup>1</sup>    |                    |                   |                    |                    | 3                 |                  |       |       |       |       |       |       |       |       |       |                |  |
| EU/Spain          | 240               | 300               | 158               | 50                 | 423 <sup>1</sup>  | 912 <sup>1</sup>  | 1020 <sup>1</sup>  | 1347 <sup>1</sup>  | 855 <sup>1</sup>   | 674 <sup>1</sup>   | 857 <sup>1</sup>   | 1049 <sup>2</sup>  | 725 <sup>2</sup>   | 997 <sup>2</sup>  | 768 <sup>1</sup>   | 406 <sup>2</sup>   | 537 <sup>1</sup>  | 507 <sup>2</sup> |       |       |       |       |       |       |       |       |       |                |  |
| EU/United Kingdom |                   |                   |                   |                    |                   |                   |                    |                    |                    |                    | 547 <sup>1</sup>   |                    |                    |                   |                    |                    |                   |                  |       |       |       |       |       |       |       |       |       |                |  |
| Faroe Is.         | 7333              | 6791              | 5993              | 8688               | 7410              | 9368              | 9199               | 7719 <sup>2</sup>  | 10228 <sup>2</sup> | 8516 <sup>2</sup>  | 12676 <sup>2</sup> | 4952 <sup>1</sup>  | 2457 <sup>1</sup>  | 1102 <sup>1</sup> | 2303 <sup>1</sup>  | 1201               | 1349 <sup>1</sup> | 495 <sup>1</sup> |       |       |       |       |       |       |       |       |       |                |  |
| France (SPM)      |                   |                   |                   |                    | 150               |                   |                    | 138 <sup>1</sup>   | 337 <sup>1</sup>   | 161 <sup>1</sup>   |                    |                    | 487                |                   | 741 <sup>1</sup>   |                    | 193 <sup>1</sup>  |                  |       |       |       |       |       |       |       |       |       |                |  |
| Greenland         | 3788 <sup>1</sup> | 2275 <sup>1</sup> | 2400 <sup>1</sup> | 1107 <sup>1</sup>  | 104 <sup>1</sup>  | 866 <sup>1</sup>  | 576 <sup>1</sup>   | 1734 <sup>1</sup>  |                    | 644 <sup>1</sup>   | 1990 <sup>2</sup>  |                    | 12 <sup>1</sup>    | 778 <sup>2</sup>  |                    |                    |                   |                  |       |       |       |       |       |       |       |       |       |                |  |
| Iceland           | 2243              | 2355 <sup>1</sup> | 7623              | 20680 <sup>1</sup> | 7197 <sup>1</sup> | 6572 <sup>1</sup> | 9277 <sup>2</sup>  | 8912 <sup>2</sup>  | 5265 <sup>2</sup>  | 5754 <sup>1</sup>  | 4715 <sup>1</sup>  | 3567 <sup>1</sup>  | 4014 <sup>1</sup>  | 2099 <sup>1</sup> |                    |                    |                   |                  |       |       |       |       |       |       |       |       |       |                |  |
| Japan             |                   |                   |                   |                    |                   |                   |                    | 114 <sup>1</sup>   | 130                | 100 <sup>1</sup>   | 117 <sup>1</sup>   |                    |                    |                   |                    |                    |                   |                  |       |       |       |       |       |       |       |       |       |                |  |
| Norway            | 7183              | 8461              | 9533              | 5683               | 1831 <sup>1</sup> | 1339 <sup>1</sup> | 2975 <sup>1</sup>  | 2669 <sup>2</sup>  | 12972 <sup>1</sup> | 11833 <sup>1</sup> | 21238 <sup>1</sup> | 11738 <sup>1</sup> | 223 <sup>1</sup>   | 890 <sup>2</sup>  | 1914 <sup>1</sup>  | 321 <sup>2</sup>   |                   |                  |       |       |       |       |       |       |       |       |       |                |  |
| Russia            |                   | 350               | 3327              | 4445               | 1090              |                   | 1142               | 7070 <sup>1</sup>  | 5687 <sup>1</sup>  | 1176 <sup>1</sup>  | 3 <sup>1</sup>     | 654 <sup>1</sup>   | 266 <sup>1</sup>   | 46 <sup>1</sup>   | 73 <sup>1</sup>    | 21 <sup>1</sup>    | 20 <sup>1</sup>   | 7 <sup>1</sup>   |       |       |       |       |       |       |       |       |       |                |  |
| Ukraine           |                   |                   |                   |                    |                   |                   |                    |                    | 348 <sup>1</sup>   |                    | 237 <sup>1</sup>   | 315 <sup>1</sup>   |                    | 282 <sup>1</sup>  |                    |                    |                   |                  |       |       |       |       |       |       |       |       |       |                |  |
| USA               |                   |                   |                   |                    |                   |                   |                    | 629 <sup>1</sup>   |                    |                    |                    |                    |                    |                   |                    |                    |                   |                  |       |       |       |       |       |       |       |       |       |                |  |
| <b>Total</b>      | 25611             | 24579             | 33471             | 48299              | 26028             | 30321             | 43439              | 52867              | 53389              | 50214              | 63970              | 45757              | 27479              | 18595             | 20741              | 13985              | 5448              | 1988             | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0 <sup>3</sup> |  |

<sup>1</sup>NAFO Statlant 21 A<sup>2</sup>From the fisheries biologist of respective countries<sup>3</sup>Reported to NAFO provisionally

\* Moratorium

**Table 2.** Exploitation Rate of Shrimp (Div. 3M) as Nominal Catches (t) divided by UE Survey Female Index (t).

|                   | Nominal Catches | UE Survey Female Index | Exploitation Rate |
|-------------------|-----------------|------------------------|-------------------|
| 1993              | 25611           | 6923                   | 3.7               |
| 1994              | 24579           | 2945                   | 8.3               |
| 1995              | 33471           | 4857                   | 6.9               |
| 1996              | 48299           | 5132                   | 9.4               |
| 1997              | 26028           | 4885                   | 5.3               |
| 1998              | 30321           | 11444                  | 2.6               |
| 1999              | 43439           | 13669                  | 3.2               |
| 2000              | 52867           | 10172                  | 5.2               |
| 2001              | 53389           | 13336                  | 4.0               |
| 2002              | 50214           | 17091                  | 2.9               |
| 2003              | 63970           | 11589                  | 5.5               |
| 2004              | 45757           | 12081                  | 3.8               |
| 2005              | 27479           | 14381                  | 1.9               |
| 2006              | 18595           | 11359                  | 1.6               |
| 2007              | 20741           | 12843                  | 1.6               |
| 2008              | 13985           | 8630                   | 1.6               |
| 2009              | 5448            | 1764                   | 3.1               |
| 2010              | 1988            | 3819                   | 0.5               |
| 2011              | 0               | 1132                   | 0.0               |
| 2012              | 0               | 791                    | 0.0               |
| 2013              | 0               | 691                    | 0.0               |
| 2014              | 0               | 716                    | 0.0               |
| 2015              | 0               | 1079                   | 0.0               |
| 2016              | 0               | 1982                   | 0.0               |
| 2017              | 0               | 2304                   | 0.0               |
| 2018              | 0               | 4051                   | 0.0               |
| 2019 <sup>1</sup> | 0               | 8486                   | 0.0               |

<sup>1</sup>Provisional to 10 September

**Table 3.** Shrimp female, cod and redfish biomass indices (t) from the EU survey series.

| Year | Female shrimp | Cod    | Redfish |
|------|---------------|--------|---------|
| 1988 | 4525          | 40839  | 188331  |
| 1989 | 1359          | 114050 | 162535  |
| 1990 | 1363          | 59362  | 126757  |
| 1991 | 6365          | 40248  | 76955   |
| 1992 | 15472         | 26719  | 130209  |
| 1993 | 6923          | 60963  | 72608   |
| 1994 | 2945          | 26463  | 162525  |
| 1995 | 4857          | 9695   | 87644   |
| 1996 | 5132          | 9013   | 119662  |
| 1997 | 4885          | 9966   | 165816  |
| 1998 | 11444         | 4986   | 70832   |
| 1999 | 13669         | 2854   | 98651   |
| 2000 | 10172         | 3062   | 177990  |
| 2001 | 13336         | 2695   | 77345   |
| 2002 | 17091         | 2496   | 121312  |
| 2003 | 11589         | 1593   | 93816   |
| 2004 | 12081         | 4071   | 250605  |
| 2005 | 14381         | 5242   | 451215  |
| 2006 | 11359         | 12505  | 766922  |
| 2007 | 12843         | 23886  | 464628  |
| 2008 | 8630          | 43675  | 566126  |
| 2009 | 1764          | 75228  | 358479  |
| 2010 | 3819          | 69295  | 212211  |
| 2011 | 1132          | 106151 | 197031  |
| 2012 | 791           | 113227 | 305946  |
| 2013 | 691           | 72289  | 219737  |
| 2014 | 717           | 163420 | 179936  |
| 2015 | 1079          | 114807 | 158001  |
| 2016 | 1982          | 80583  | 171199  |
| 2017 | 2304          | 89414  | 163262  |
| 2018 | 4051          | 75621  | 100484  |
| 2019 | 8486          | 42460  | 143298  |



**Table 4.** Abundance (10<sup>6</sup>) at age by years in EU Flemish Cap surveys.

| Age   | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 <sup>1</sup> | 1995 | 1996 | 1997 | 1998 <sup>2</sup> | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |   |   |
|-------|------|------|------|------|------|------|-------------------|------|------|------|-------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|---|---|
| 1     |      |      |      |      |      |      |                   |      |      |      | 94                | 1    | 9    | 3    | 181  | 14   |      |      |      |      |      |      | 8    |      |      | 1    |      |      | 0    |      |      | 1    |   |   |
| 2     |      |      |      |      |      |      |                   |      | 342  | 63   | 5497              | 474  | 107  | 332  | 1100 | 1257 | 2742 | 179  | 58   | 30   | 22   | 118  | 111  | 60   | 23   | 6    |      | 111  | 23   | 69   | 91   | 107  |   |   |
| 3     | 13   | 1    |      | 47   | 159  | 788  | 43                | 243  | 857  | 289  | 4235              | 2392 | 1704 | 1877 | 4787 | 1774 | 960  | 6903 | 301  | 387  | 646  | 161  | 418  | 90   | 89   | 18   | 35   | 41   | 109  | 128  | 163  | 606  |   |   |
| 4     | 123  | 82   | 404  | 260  | 146  | 376  | 88                | 276  | 153  | 241  | 707               | 1496 | 1074 | 2015 | 1128 | 548  | 643  | 524  | 1949 | 1221 | 857  | 169  | 275  | 109  | 56   | 60   | 43   | 93   | 214  | 245  | 191  | 539  |   |   |
| 5     | 233  | 81   | 92   | 465  | 440  | 205  | 73                | 120  | 273  | 322  | 789               | 601  | 572  | 1184 | 1047 | 907  | 783  | 1050 | 1205 | 1276 | 575  | 91   | 24   | 31   | 11   | 40   | 42   | 17   | 49   | 11   | 132  | 140  |   |   |
| 6     | 163  | 83   | 33   | 389  | 1129 | 446  | 181               | 215  | 65   | 115  | 414               | 204  | 349  | 323  | 311  | 243  | 133  | 758  | 522  | 588  | 40   | 25   | 0    | 0    | 1    | 3    | 6    | 9    | 6    |      | 29   | 4    |   |   |
| 7     | 15   | 11   | 2    | 103  | 398  | 49   | 8                 | 122  | 44   | 16   | 15                | 8    | 61   | 16   | 55   | 9    | 21   | 141  | 65   | 129  |      | 7    | 0    | 0    |      |      |      |      |      |      | 5    | 2    |   |   |
| 8     |      |      |      | 33   |      |      |                   |      |      |      |                   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      | 1 |   |
| 9+    |      |      |      |      |      |      |                   |      |      |      |                   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |   | 1 |
| Total | 548  | 258  | 530  | 1296 | 2271 | 1864 | 391               | 976  | 1734 | 1046 | 11751             | 5177 | 3876 | 5750 | 8608 | 4753 | 5281 | 9554 | 4098 | 3631 | 2141 | 570  | 828  | 290  | 179  | 128  | 125  | 271  | 401  | 452  | 612  | 1416 |   |   |

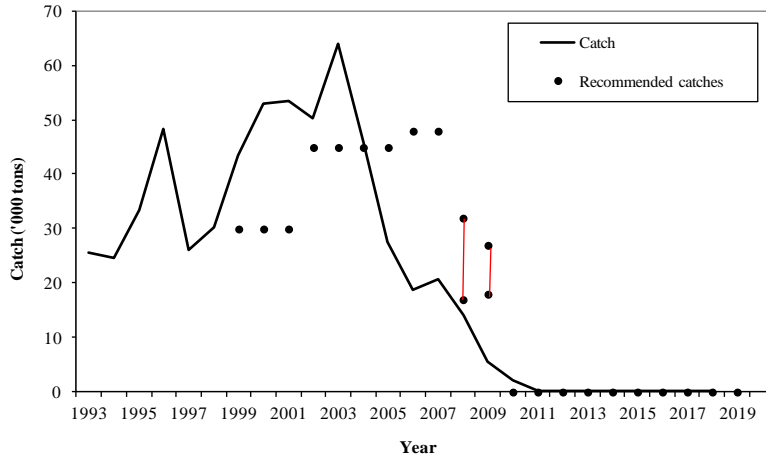
<sup>1</sup>Codend mesh-size 40 mm.<sup>2</sup>Codend mesh-size 25 mm.**Table 5.** Biomass estimated (tons) at age by years in EU Flemish Cap surveys.

| Age   | 1988 | 1989 | 1990 | 1991  | 1992  | 1993  | 1994 <sup>1</sup> | 1995 | 1996  | 1997 | 1998 <sup>2</sup> | 1999  | 2000  | 2001  | 2002  | 2003  | 2004  | 2005  | 2006  | 2007  | 2008  | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |    |    |
|-------|------|------|------|-------|-------|-------|-------------------|------|-------|------|-------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|------|------|------|------|------|------|------|----|----|
| 1     |      |      |      |       |       |       |                   |      |       |      | 60                | 1     | 6     | 2     | 114   | 6     |       |       |       |       |       |      | 9    |      |      |      |      |      |      |      |      |      | 1  |    |
| 2     |      |      |      |       |       |       |                   |      | 609   | 139  | 9039              | 832   | 183   | 572   | 2178  | 2541  | 4660  | 187   | 57    | 38    | 33    | 303  | 373  | 177  | 63   | 21   |      | 359  | 65   | 190  | 267  | 243  |    |    |
| 3     | 44   | 2    |      | 166   | 610   | 2144  | 145               | 685  | 4552  | 1270 | 16203             | 7811  | 5924  | 5018  | 16710 | 7134  | 3730  | 15782 | 586   | 837   | 2094  | 600  | 2230 | 461  | 450  | 85   | 141  | 228  | 535  | 651  | 903  | 3152 |    |    |
| 4     | 575  | 387  | 2053 | 1214  | 705   | 2083  | 554               | 1658 | 1071  | 1705 | 4099              | 9016  | 5233  | 9992  | 6436  | 2762  | 3969  | 2109  | 5882  | 4764  | 4491  | 892  | 2054 | 726  | 431  | 379  | 316  | 687  | 1395 | 1920 | 1460 | 4215 |    |    |
| 5     | 2377 | 626  | 888  | 3843  | 3683  | 1823  | 681               | 892  | 2703  | 2853 | 5719              | 4784  | 3838  | 8321  | 7758  | 6197  | 6206  | 5702  | 5547  | 6330  | 4084  | 635  | 227  | 250  | 104  | 323  | 379  | 179  | 450  | 124  | 1353 | 1530 |    |    |
| 6     | 2334 | 1053 | 436  | 4094  | 13637 | 4948  | 2374              | 2313 | 827   | 1249 | 4038              | 2138  | 3112  | 3087  | 2696  | 2339  | 1430  | 5531  | 3606  | 3971  | 390   | 224  | 0    | 5    | 7    | 35   | 64   | 98   | 75   |      | 333  | 54   |    |    |
| 7     | 285  | 183  | 28   | 1478  | 5801  | 675   | 124               | 1728 | 700   | 234  | 207               | 112   | 706   | 215   | 616   | 108   | 254   | 1365  | 621   | 1105  | 0     | 81   | 0    | 0    | 0    | 0    |      |      |      |      | 79   | 31   |    |    |
| 8     |      |      |      | 557   |       |       |                   |      |       |      |                   |       |       |       |       |       |       |       |       |       |       |      |      |      |      |      |      |      |      |      |      |      | 14 |    |
| 9+    |      |      |      |       |       |       |                   |      |       |      |                   |       |       |       |       |       |       |       |       |       |       |      |      |      |      |      |      |      |      |      |      |      |    | 35 |
| Total | 5615 | 2252 | 3405 | 11352 | 24436 | 11673 | 3879              | 7276 | 10461 | 7449 | 39365             | 24695 | 19002 | 27206 | 36508 | 21087 | 20248 | 30675 | 16299 | 17045 | 11092 | 2735 | 4893 | 1619 | 1055 | 844  | 900  | 1551 | 2521 | 2885 | 4394 | 9273 |    |    |

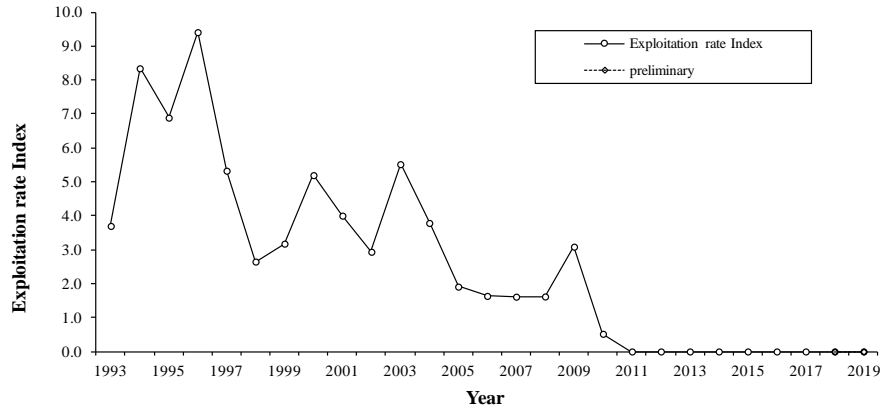
<sup>1</sup>Codend mesh-size 40 mm.<sup>2</sup>Codend mesh-size 25 mm.

**Table 6.** Abundance at age 2 and average-weighted as indicator of recruitment (R) in the survey (lofoten gear) and from juvenile bag.

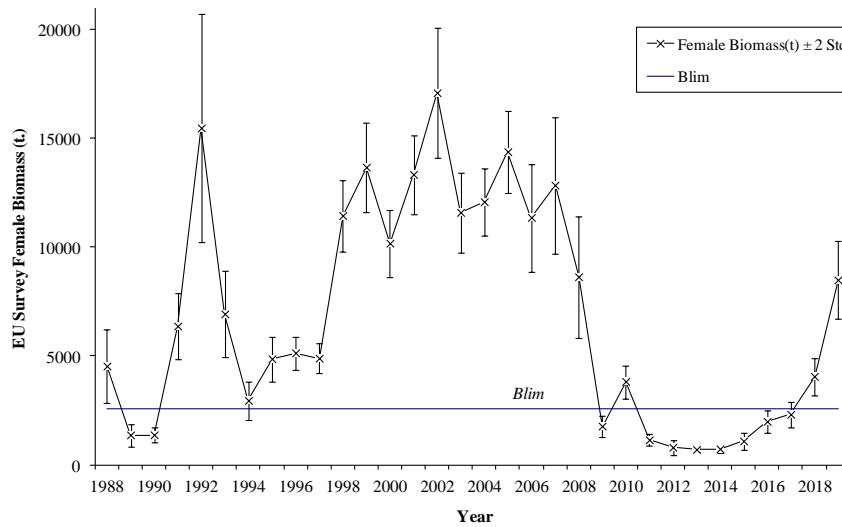
| year | R (age 2)<br>juvbag<br>(‘000) | R (age 2)<br>Lofoten<br>(‘00000) | R(2)juvbag<br>Av_weighted | R(2)lofoten<br>Av_weighted |
|------|-------------------------------|----------------------------------|---------------------------|----------------------------|
| 1996 |                               | 3424                             |                           | 1.06                       |
| 1997 |                               | 629                              |                           | 0.19                       |
| 1998 |                               |                                  |                           |                            |
| 1999 |                               | 4735                             |                           | 1.46                       |
| 2000 |                               | 1069                             |                           | 0.33                       |
| 2001 | 1361                          | 3321                             | 0.33                      | 1.03                       |
| 2002 | 2125                          | 11004                            | 0.52                      | 3.40                       |
| 2003 | 0                             | 12572                            | 0.00                      | 3.89                       |
| 2004 | 41818                         | 27415                            | 10.18                     | 8.48                       |
| 2005 | 3741                          | 1792                             | 0.91                      | 0.55                       |
| 2006 | 7498                          | 582                              | 1.82                      | 0.18                       |
| 2007 | 3824                          | 301                              | 0.93                      | 0.09                       |
| 2008 | 4969                          | 221                              | 1.21                      | 0.07                       |
| 2009 | 3011                          | 1177                             | 0.73                      | 0.36                       |
| 2010 | 954                           | 1103                             | 0.23                      | 0.34                       |
| 2011 | 2440                          | 601                              | 0.59                      | 0.19                       |
| 2012 | 160                           | 229                              | 0.04                      | 0.07                       |
| 2013 | 102                           | 63                               | 0.02                      | 0.02                       |
| 2014 | 56                            | 0                                | 0.01                      | 0.00                       |
| 2015 | 427                           | 1111                             | 0.10                      | 0.34                       |
| 2016 | 390                           | 230                              | 0.09                      | 0.07                       |
| 2017 | 1411                          | 695                              | 0.34                      | 0.21                       |
| 2018 | 552                           | 1049                             | 0.13                      | 0.32                       |
| 2019 | 3230                          | 1028                             | 0.79                      | 0.32                       |



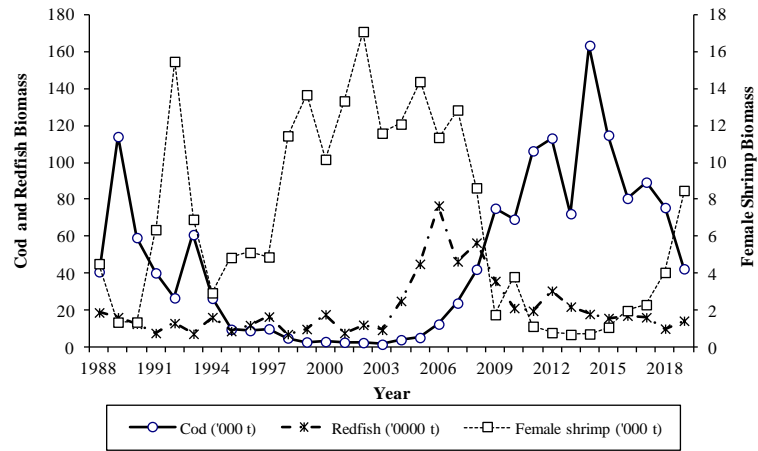
**Figure 1.** Catches (t) of shrimp on Flemish Cap and catches recommended in the period 1993-2019. Due to a moratorium, the shrimp catch is expected to be zero in 2019.



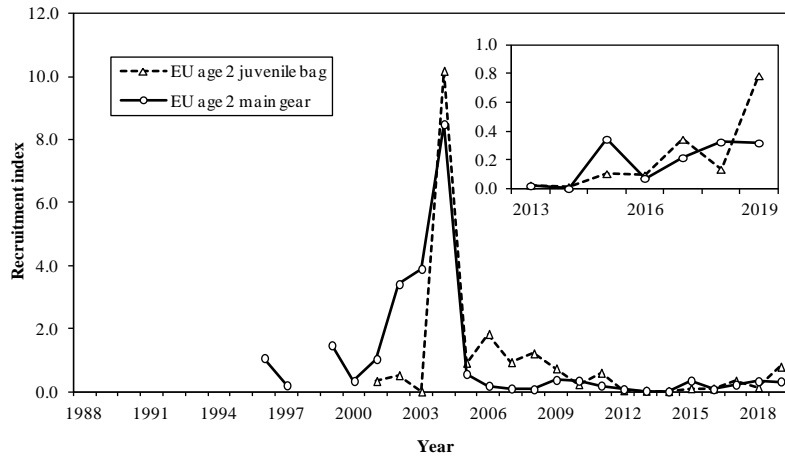
**Figure 2.** Exploitation rates as nominal catch divided by the EU survey biomass index of the same year.



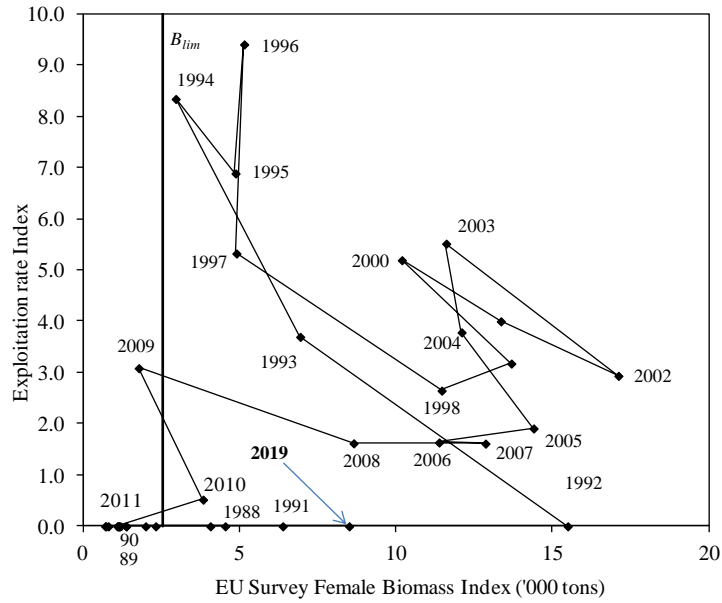
**Figure 3.** Female biomass index from EU surveys, 1988-2019.



**Figure 4.** Cod, Redfish and Female shrimp biomass from EU trawl surveys, 1988-2019.



**Figure 5.** Recruitment indices, abundances of age 2 in EU Survey from main gear and juvenile bag. Each series was standardized to its mean.



**Figure 6.** Exploitation rate index plotted against female biomass index from EU survey. Line denoting  $B_{lim}$  is drawn where biomass is 15% of the maximum point in 2002. Due to the moratorium on shrimp fishing the expected catch in 2019 is 0 t.