Changes in lenght structure and spatial distribution of some demersal species in the Northwest Atlantic (Divs. 3NO and 3L, NAFO Regulatory Area) during the last decade.

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INTRODUCTION

Many commercial species (cod, haddock, flounder, redfish, thorny skate, Greenland halibut) are distributed in the area of the Grand Banks of Newfoundland (NAFO Divs. 3LNO) which is characterized as biologically rich and productive, from the shallow depths to the bottom. All of this species are highly dominant because of their biomass or by its role in the community, have experienced several collapses since the 60's up to the current situation (Rice,2002). As one component of the ecosystem affects the whole, it is expected that the decrease in biomass of these species, has an influence in other species that make up the ecosystem of the Grand Banks. The aim of this study is to analyze the observed changes in the last decade in several species, some of which are not even commercial species.

MATERIAL & METHODS

Data used came from the Spanish surveys (Platuxa and Fletan Negro) conducted in international waters in the NAFO Regulatory Area, Divs. 3NO and 3L, in the spring-summer period during the years 2002-2010 (González-Troncoso *et al.*, 2010; Román *et al.*, 2010). The species of this study follow different patterns: a widely distributed species, such as thorny skate (*Amblyraja radiata*), deep-water species such as grenadiers (*Macrourus berglax*, *Coryphaenoides rupestris*, *Nezumia bairdii*), and an opportunistic species like arrowtooth eel (*Synaphobranchus kaupii*). To simplify the analysis by depth, and due to the large number of strata in NAFO, we made a grouping, leaving only 5 strata, covering the following depth ranges: 0-91 m., 93-274 m., 275-549 m., 550-914 m., 915-1500 m. In order to simplified the analysis length ranges of 10 cm. were used: <10, 10-19, 20-29, 30-39, 40-49, 50-59 and ≥ 60 cm. The changes in abundance, in length structure, and changes in depth distribution were analyzed. The results are compared with the temperature variations in the area.

NAFO MAP

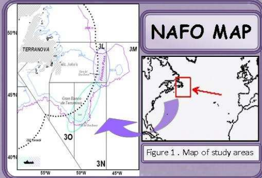
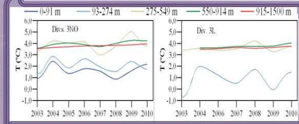


Figure 1 . Map of study areas

TEMPERATURE BY STRATUM



There is geographic variation in temperature between Divs. 3NO and 3L for the same strata depth, slightly higher in Divs. 3NO. There was annual significant differences (Kruskal-Wallis test, p ≤ 0.001) in temperature in each area at same depth in the period 2002 - 2010, and also temperature differences among strata of each area , including the two deepest strata.

Figure 2 Mean temperature by depth stratum in Divs 3NO and 3L in the period 2002-2010

BATHYMETRIC DISTRIBUTIONS

A. radiata. Different depth range of distribution in both areas, but always covering all depths (the depth in international waters of Div 3L is greater than 93 m). Different distribution dependent length. The smaller individuals are scarce from 550 m onwards. In Div 3L abundance is similar from 93 to 549 m, and in recent years, it has tended to increase its presence from 93 to 274 m and decrease in the next stratum. However, in Divs. 3NO, abundance (mainly distributed at <93 m) has tended to increase at this depth and decrease at greater depths. In this area, in 2009, is remarkable the increase of individuals from 275 to 914 m. where the temperature was higher than habitual.
In both areas, the distribution in depths greater than 550 m is only highlighted in the early years (distribution of spring), being scarce in depths lower than this (distribution of summer).
This latter aspect is observed in other species, but is notable in the *A.radiata* and *M. berglax*.

M. berglax The same depth range of distribution in both areas (93-1500 m), but with different abundance along bathymetric distribution. No bathymetric differences in length distribution. In Divs 3NO, this species is mostly distributed in depths greater than 900 m and its abundance is scarce in less than 275 m. In Div 3L abundance is similar from 275 to 1500 m, even there is a considerable presence in less than 275 m. In both areas the presence decreased from 275 to 549 m. It is observed a movement to less depths in Div 3L and the opposite in Divs 3NO.

C. rupestris. The same depth range of distribution in both areas (93-1500 m), but with different abundance along bathymetric distribution. No bathymetric differences in length distribution. The abundance of this species is scarce in depths from 93 to 549 m and it is mostly distributed in depths from 915 to 1500 m in both areas. In the latest years the species trend is to be in lower depths. Its presence from 93 to 274 m is anecdotic in both areas (only 2006). However, it has been present from 275 to 549 m since 2002 in Divs 3NO, while in Div 3L it has been from 2006 onwards..

N. bairdii. The same depth range of distribution in both areas (93-1500 m). No bathymetric differences in length distribution. In both areas abundance of this species is scarce in depths from 93 to 274 m and it is more abundant in depths from 550 to 914 m .In the other depth strata, the abundance is greater in 3NO than in 3L. In the latest years the species has moved in both areas. In Divs 3NO, the presence has decreased in 550-914 m stratum, going to more depth strata and also to shallower strata. Contrarily, in Div 3L, the presence has increased in 550-914 m stratum coming from other depths.
The presence from 275 to 274 m has been observed in Divs 3NO since 2002, however in Div 3L it has been from 2006 onwards.

S. kaupii. The same depth range of distribution in both areas (275-1500 m). No bathymetric differences in length distribution. In both areas abundance of this species is scarce in depths from 275 to 549 m and it is mostly distributed in depths from 915 to 1500 m. In the period analyzed, the abundance at preferred depth showed inter-annual fluctuations mismatched in both areas, but with the same answer: when it decreases it moves to the previous stratum.
The presence from 275 to 549 m has been observed in both areas, only from 2006 onwards.

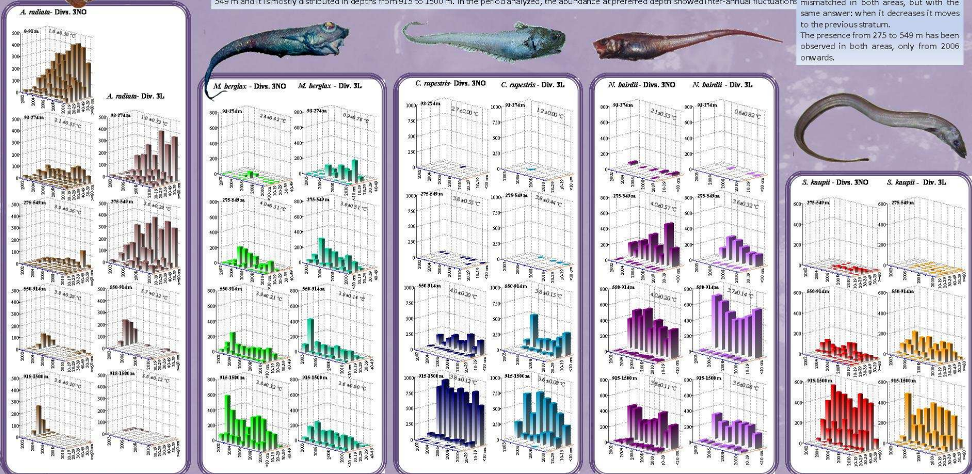


Figure 3 Annual abundance (‰) of each length group (cm) by depth stratum, showing mean temperature (Divs. 3NO and 3L, period 2002-2010).

LENGTH DISTRIBUTIONS

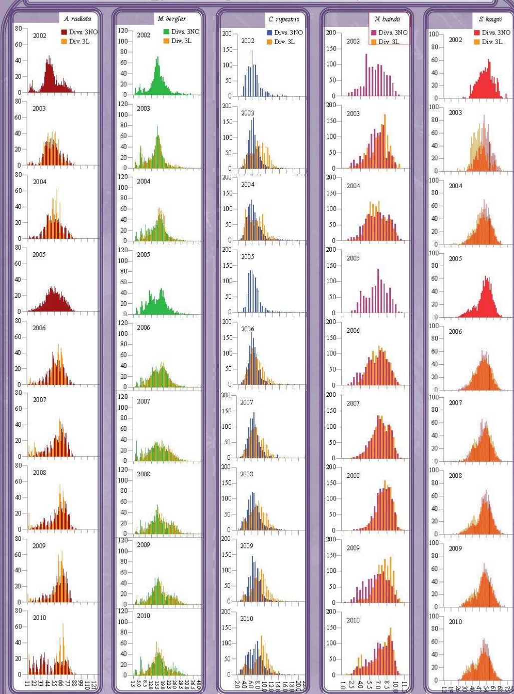


Figure 4 . Length distribution (‰) of populations in Divs 3NO and 3L during the period 2002-2010.

A. radiata. Different length structure along the period in both areas. Different annual recruitment and more abundant in Div 3L since 2006. In this division, length range is slightly lower and the abundance is greater in individuals from 55 to 75 cm.

M. berglax. Similar length structure and similar temporal evolution in both areas. Low growth. The populations changed from one strong mode before 2005 to be bimodal in 2005-2007 and afterwards again to one mode, wide and little marked. Low abundance in individuals of big length.

C. rupestris. Geographic differences in length structure. The small individuals are more abundant in Divs 3NO with a unimodal distribution and the biggest ones are more abundant in Div 3L showing the second mode of this population (the first one is smaller and come from the small individuals, even recruits). Low growth, unimodal except in latest years in Div 3L. Low abundance in individuals of big length.

N. bairdii. Similar demographic structure and similar temporal evolution in both areas, except year 2009 with the presence of smaller individuals than modal length in Divs 3NO, which do not appear in Div 3L nor the following year in Divs 3NO. Unimodal population, whose mode appears in adult fraction in latest years because of the increase of biggest individuals abundance

S. kaupii. Similar length structure and similar temporal variation in both areas, except year 2003 with the presence, in Divs 3NO, of individuals showing a mode of smaller length than the mode showing in Divs 3NO, but disappearing the following year. Inter-annual variation is very little. In the latest years, the smallest individuals has increased (recruitment).

DISPERSION GRAPHICS

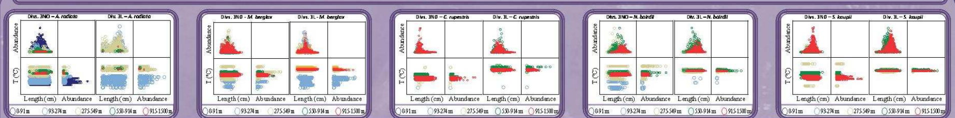


Figure 5 Abundance, length and temperature relationship

Abundance and temperature relationship The behavior of analysed species was different and with geographic variations.
- ***A. radiata***. Both variables were significatively relationated, but positively in Div. 3L (partial correlation controlling depth effect , r = 0.07 p≤0.05).and negatively in Divs. 3NO (r = -0.19 p≤0.001). - ***M. berglax***. Negative and non significant correlation in Div. 3L, and very little correlation in Divs. 3NO. - ***C. rupestris***. Negative correlation in both areas but only significant in Divs. 3NO (r = -0.09 p≤0.001). - ***N. bairdii***. Positive correlation in both areas but only significant in Divs. 3NO (r = 0.21 p≤0.001). - ***S. kaupii***. Negative and significant correlation in Divs. 3NO (r = -0.15 p≤0.001), and very little correlation in Div. 3L.

CONCLUSIONS

The length composition and the observed changes in the period 2002 - 2010 in the populations of *M. berglax*, *N. bairdii* and *S. kaupii* indicate similar process across the area covered by the Divs. 3NO and 3L. The opposite happens in the *A. radiata* and *C. rupestris*, species that show geographic differences in population structure. In both cases we find, throughout an area where a considerable fleet has operated for decades, commercial species as well as noncommercial, so, other factors, besides the influence of fishing, has influenced the changes.
The temperature increases with depth, although from 550 m varies little. In addition, the temperature is slightly lower in the northeast (Div. 3L) at similar depth. It must bear in mind that the periods in which the surveys have been conducted have varied, from early spring in first years to summer in the latest (early summer in Divs. 3NO and late summer in Div 3L) (González-Troncoso *et al*, 2010, Roman *et al*., 2010). In the period under analysis there were fluctuations in temperature, obviously greater in lower depths. These temperature changes mark a slightly increasing trend in depths greater than 275 m, and decreasing trend in shallower depths.
The temperature affects the changes in bathymetric distribution of the species studied. The most important are the seasonal movements, clear in thorny skate, in which there is a large distribution at great depths in the first years studied (2003 and 2004) and at shallower depths in recent years (this is the distribution of summer). This fact affects less to the other species studied here because they have their habitat at a great depth throughout the year.
At great depths the temperature varies less, but small changes have a bigger impact on the optimal conditions for each species (temperature tolerance, feed, etc.). Changes in species abundance between close depth ranges denote the influence of fluctuations in inter-annual temperature, especially in the movement of individuals between the last three deepest strata (from 275 to 1500 m). Depending on the temperature range preferred by each species, the population shows their movements towards more or less depth searching the required temperature. So, if there is similar temperature over a large bathymetric range, this allows individuals to be widely distributed.
All the three grenadiers as well as *S. kaupii* show a trend to increase its presence (always in low abundance values) in shallower depths. These movements would not be linked to densodependent effects, since biomass of some of these species has declined.
These distribution changes could be related to temperature, but other factors must be taken into account (fishery, changes in abundance of competing species or predators, etc).

REFERENCES

González-Troncoso, D.; E. Román and X. Paz. 2010. Results for Greenland halibut and American plaice of the Spanish survey in NAFO Div. 3NO for the period 1997-2009. *NAFO SCR Doc.* 10/08, Serial No. N5757

Rice, J.,2002. Changes to the Large Marine Ecosystem of the Newfoundland-Labrador Shelf. Large Marine Ecosystems of the North Atlantic. K. Sherman and H.R. Skjoldal (Editors)

Román, E.; C. González-Iglesias and D. González-Troncoso. 2010. Results for the Spanish Survey in the NAFO Regulatory Area of Division 3L for the period 2003-2009. *NAFO SCR Doc.* 10/15, Serial No. N5768

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