Climate changes and the distribution of the northern shrimp (*Pandalus borealis*)

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**Summary**

In this study, the distributional pattern of northern shrimp (*Pandalus borealis*) on Icelandic fishing grounds was investigated by calculating the center of gravity CG for each from 1988 to 2012. The CG was then used as a response variable to see which environmental factors are likely to be affecting the direction of movement. Factors such as sea surface and bottom temperature were of main interest but other factors, such as cod abundance on the shrimp fishing ground and the total shrimp catch were also investigated. The timeline was divided in two eras. First, the years between 1988 to 2000, when the movement of the CG is in a southeastern direction, moving towards land. Secondly are the years from 2001 to 2012 when the direction is in a northwestern direction, moving away from land. A linear model showed only shrimp catch to be affecting the movement, explaining 59.7% of the observed variation. No significant relationship was found between ocean temperature and the direction of movement in neither direction. The overall movement is likely to be caused by a combination of multiple factors and needs further investigation.

**Introduction**

The northern shrimp (*Pandalus borealis*) is distributed through the colder parts of the North Atlantic and Pacific Oceans. It is found both inshore and offshore in Icelandic waters and its preferred temperature range is 0-6°C. In recent years, or since 1995, surface temperature on Icelandic fishing grounds has increased by 2-4°C and for species with a limited distributional range, a relatively small increase can have devastating consequences. Changes in assemblage structure in the waters around Iceland has been noticed (Stefansdottir et al., 2010), new species have been recorded more frequently and other species found to be relocating (Astthorsson et al., 2012). The northern shrimp stock on Icelandic fishing grounds has remained low in the past years after a collapse in 2004. Repeated recruitment failure, due to increased cod abundance and changes in temperature, may have lead to slow recovery of the northern shrimp stock (Jónsdóttir, et al, 2013). The main objective of this present study is to investigate whether changes in temperature influenced the distribution of northern shrimp in Icelandic waters.

**Materials and Methods**

The annual shrimp survey (SMR) is conducted in July-August by the Marine Research Institute (MRI). The SMR covers the north and the northeast areas of the Icelandic continental shelf and slope, at depths from 200 to 700m. It is a stratified systematic survey where the same 92 stations are repeated annually. At each station, shrimp catch was weight and a subsample of approximately 250 individuals were measured and the subsample weighed. Depth was recorded at each station and the sea bottom temperature determined using a pre-calibrated trawl sensor attached to the trawl headline. The Sea surface temperature SST is measured using a platinum resistance thermometer (PT100). The mean temperature was calculated for all years. The shrimp biomass index and the cod abundance index were calculated using a standard area swept method. The center of gravity (CG) was calculated for each year to examine the spatial movement of shrimp between years. The coordinates of the CG are computed as:
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CG = \left\{ \frac{\sum_i u_i z_i}{\sum_i z_i}, \frac{\sum_i v_i z_i}{\sum_i z_i} \right\}
\]

where \(u_i\) is the longitude, \(v_i\) is the latitude and \(z_i\) is the observed density at each sampling location \(i\).

The study covers a total of 25 years or from year 1988 to 2012. It was then divided in two eras for further analysis depending on the direction of movement.

**Results and discussion**

The center of gravity does not reflect any major directional shift and seems to be located at a relatively similar grounds north of Iceland. In the years from 1988 to 2000 the CG moves towards land in a southeastern direction. The following years from 2001 to 2012 the CG moves back away from land in a northwestern direction (Figure 1).

The mean sea surface temperature, where the center of gravity is positioned each year, fluctuates from 5.71-9.15°C. The mean bottom temperature varies less, or from 0.73-2.18°C (Figure 2). A linear model did not indicate a significant relationship between ocean temperature and the direction of movement of the CG for neither time eras.

Shrimp catch was the only environmental variable found to have a significant relationship with the direction of movement, explaining 59.7% of the observed variation. That indicates that both fishing and the declination of the shrimp stock is affecting the movement. The greatest abundance caught each year is at a relatively similar grounds as the position of the CG. Therefore, shrimp catch as a covariate needs to be further investigated.

**References**

