Increase in natural mortality of the Iceland scallop (*Chlamys islandica*) in West Iceland and collapse of the fishery in the early 2000s

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Introduction - Collapse

The Iceland scallop *Chlamys islandica* is distributed within the sub-arctic transitional zone where maximum sea temperatures of 12–15°C have been recorded. In Iceland, the annual bottom sea temperature during the period 1970-1995 has ranged from 0 to 10°C on the various scallop grounds but increased from 1995, reaching its maximum of 11-12°C in the 2000s.

The fishery for Iceland scallop started in the highly productive fjord Breidafjördur (Fig. 1), West Iceland, in 1970 and was conducted until 2003 when a fishing moratorium was enforced due to over 50% decrease in stock abundance from 2000-2002. The annual landings reached a maximum of 12.700 tonnes in the mid-1980s but had stabilized at about 9.000 tonnes in the 1990s. The fishery of this slow growing scallop was stable compared to 'boom and bust' cycles of many scallop fisheries.

Survey indices declined drastically between 2001-2008 resulting in indices amounting to only 13% of the average for 1995-2000. Concurrently, the recruitment index (~ 1yr) dropped to less than 2% and CPUE to 45% of the average for 1995-2000 (Fig. 2).

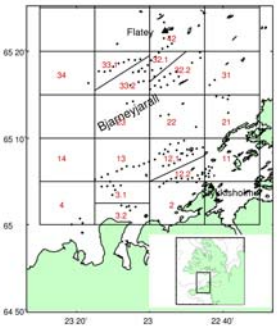

Figure 1. Map of scallop fishing grounds in Breidafjördur. Survey stations are marked with dots.

Temperature increase – Scallop tolerence

The period 1996 to 2003 was characterized by a steady increase in summer sea bottom temperatures, reaching 12.2°C on scallop beds in 2003 and remaining high at 11-12°C in the following years, the highest estimated level for over a century in West Iceland. These temperatures even exceed any period of the warm era between 1925-1965.

An experimental study showed that scallops collected during late summer can tolerate temperatures up to 13°C, at least for up to 21 days, but there was considerable mortality at 14°C. Therefore, the direct effects of increasing sea temperature are not considered to be the sole factor responsible for the mortality and dramatic decline of the Iceland scallop stocks during the 2000s.

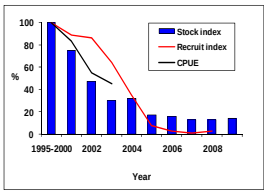

Figure 2. Stock and recruit indices and CPUE for Iceland scallop as percentages of mean values from 1995-2000.

Figure 3. Muscles from two equally sized Iceland scallops. Normal (upper) and heavily infected with visible pathological signs (lower).

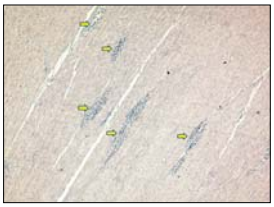

Figure 4. Shell adductor muscle: Cluster of parasites in the extracellular space.

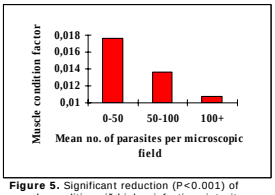

Figure 5. Significant reduction (P<0.001) of muscle condition við higher infections intesity.

Parasites – High prevalence

A previously unknown apicomplexan parasite was observed in all sizes of scallops. Infections were much more prevalent (95 - 100%) and severe in larger shells (> 60 mm shell length). Primary target organ of the parasite is the adductor muscle (Figs. 3 and 4), in which significant reduction in condition was observed with higher infection intensity (Fig. 5).

Poor scallop condition

Up to 80% of larger shells showed gross pathology in adductor muscles. Intracellular infections were also common in haemocytes. In addition to negative impact on muscle condition, the parasite seemed to hamper normal gonad development, presumably making the scallops unable to spawn.

The downward trend in stock abundance is considered to be due to mass mortality caused by this unknown apicomplexan parasite in adult scallops and poor recruitment which is likely to be connected with the infections. The infections are possibly enhanced by changing environmental conditions.

Reduced parasite intensity

Reduced infection intensity has been observed in the last year as muscle and gonad condition are approaching normal. However the spawning stock is very small and due to the slow growth of the species it may take some years for the stock to recover and fisheries to reopen.

Increased temperature since around the mid-1990s may have made the scallops more susceptible to infections. Furthermore, it could have created more favourable conditions for the apicomplexan parasite to proliferate inside the shells, resulting in the observed mass mortality and recruitment failure in the Iceland scallop stock. Witnessed and predicted ocean warming could result in complex indirect effects which are often hard to predict.