

Research Article

Observation of Long Rough Dab (*Hippoglossoides platessoides*) Eggs in Kongsfjorden, Svalbard

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The long rough dab (*Hippoglossoides platessoides*) is one of the most common bottom dwelling fish species in the Barents Sea with a limited commercial value, even though it is regularly caught as bycatch. Adult *H. platessoides* can be found in large numbers along the west coast of Svalbard, but nothing is known about the spawning area of this species or the distribution of their eggs and larvae within Svalbard fjords. Recent findings of *H. platessoides* eggs in Kongsfjorden indicate that a spawning population exists either within the fjord or on the west Spitsbergen shelf.

1. Introduction

The long rough dab (*Hippoglossoides platessoides*) is boreo-arctic species and one of the most abundant pleuronectiform fishes in the Barents Sea [1]. It is a common bycatch species in bottom trawl surveys [2, 3] but has low commercial value for fisheries [4]. The overall distribution ranges from the southeast Barents Sea to the continental slope of the Norwegian Sea and from Norwegian and Russian coastal areas to the north of Svalbard [1, 4]. The average preferred depth ranges between 50 and 550 m, with most of them occurring between 100 and 300 m [2, 4, 5]. *Hippoglossoides platessoides* can tolerate water temperatures from -1.8°C to 7°C but is most abundant from -0.5°C to 4.0°C [1, 4, 6]. Three major currents affect the distribution and spawning behaviour of *H. platessoides* in the Barents Sea: the North Atlantic Current (NAC) with its warm and highly saline waters ($S > 35$), the Norwegian Coastal Current (NCC), which has lower salinity ($S < 34.7$), and the cold East Spitsbergen Current (ESC) [7]. Along the west coast of Svalbard, the NAC splits into the West Spitsbergen Current (WSC) and meets the ESC (Figure 1). The polar front where the cold Arctic ESC and warm Atlantic NAC waters meet appears

to be an area of high concentration of this species due to high primary production [2]. Overall spawning mainly occurs in the western and central Barents Sea [7]. A general east-west migration of *H. platessoides* between the polar front and spawning grounds in the Barents Sea has been suggested [2] but has never been validated. Furthermore, it is unknown whether *H. platessoides* around Svalbard and Bear Island display similar migration patterns [2]. Dolgova and Albert [4] did not report extensive migration movement for this species.

Spawning in the Svalbard area is thought to occur from March to July [8] and is related to increasing water temperature and day length. The average spawning temperature in the Svalbard area and Barents Sea is 2°C although higher mean spawning temperatures were measured on the continental shelf around Iceland (4.5°C) and in the North Sea ($<7^{\circ}\text{C}$) [8]. Long rough dab eggs float in the upper water layers until hatching [8]. The egg shape is very characteristic and unique among fish eggs with a wide perivitelline space around the yolk and no oil globule (Figure 2; [9, 10]). The egg size in the Barents Sea ranges from 1.4 to 2.6 mm, and the hatch size of the larvae varies from 4 to 6 mm at a bottom spawning temperature of $1\text{--}3^{\circ}\text{C}$. Hatching occurs after 11–14 days at 4°C [11].

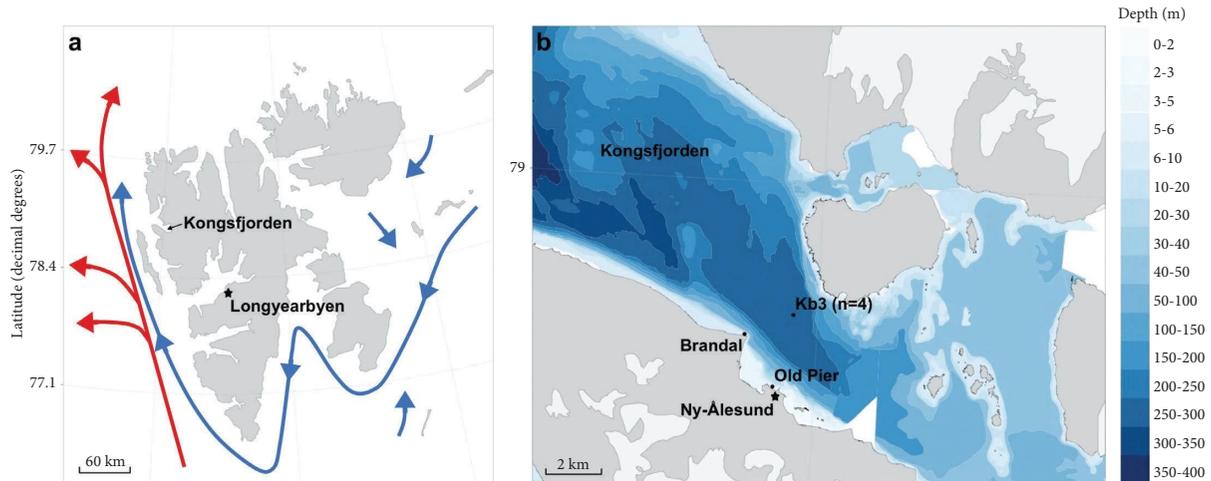


FIGURE 1: (a) Map of Svalbard with the major currents, the warm West Spitsbergen Current (red) and the cold East Spitsbergen Currents (blue). (b) Overview of sampling sites in Kongsfjorden, Svalbard. The number in parenthesis indicates the number of long rough dab eggs caught.

Small catches of 0-group individuals on the west coast of Svalbard are rare, but known [7]. There are no documented egg findings along the west coast or within the fjords of Svalbard. Therefore, the region is currently not considered a spawning area for *H. platessoides*.

An overall trend of increasing water temperatures in Arctic waters has been observed with the warmest temperatures in the Barents Sea recorded so far, affecting the local ecosystem and introducing boreal fish species [12]. Warm water periods might have affected the extension of spawning grounds of *H. platessoides* along the west coast of Svalbard and within fjords. In Atlantic-influenced fjords such as Kongsfjorden, observed increasing water temperatures could favour appearance and survival of eggs [13, 14].

In this study, we describe the occurrence of *H. platessoides* eggs captured during ichthyoplankton sampling aimed at gadoid fish eggs and larvae in Kongsfjorden, indicating either undescribed or expanded nearby spawning grounds.

2. Materials and Methods

2.1. Study Area. Kongsfjorden is located on the west coast of Svalbard at 79° N. It is oriented from NW to SE and shares its mouth with Krossfjorden. Neither of the fjords have a sill, allowing free water mass exchange with the adjoining ocean. The West Spitsbergen Current (WSC) runs along the continental slope of Svalbard, bringing warm saline ($S > 35$) water masses into the fjord. Cold Arctic water is transported from the north towards the west Spitsbergen shelf and flows into Kongsfjorden. Here, these water masses mix with fresh water from melting glaciers and riverine outflows.

Three different sampling sites were chosen in Kongsfjorden to assess the ichthyoplankton community (see Figure 1): one sampling site in the middle of the fjord (Kb3; 78°57.24' N, 11°57.38' E, sampling depth 0–50 m, and bottom depth approximately 300 m), a second sampling site in the shallow water (<10 m deep) with a known rocky bottom



FIGURE 2: Section of the *H. platessoides* egg, the head and front part with yolk sac.

and an associated algae cover (Old Pier), and a third sampling site with a sandy bottom (<10 m deep; Brandal).

Plankton sampling was conducted between 1 May and 16 July 2020. The station Kb3, which is used regularly for plankton monitoring, was chosen for the primary sampling over the entire period (see Figure 1). Until 26 June 2020, sampling was performed twice a week and then four times a week thereafter. From 1 July 2020, a shallow water (less than 10 m deep) transect approximately 300 m long was sampled twice per week close to the settlement Ny-Ålesund between Old Pier and the Ny-Ålesund harbour (78°55.715' N, 11°55.518' E). This sampling site was added to potentially catch fish larvae on their way to shallow water settlement areas. Brandal, a third sampling site west of Ny-Ålesund (78°56.789' N, 11°52.192' E), was sampled once on 6 July 2020. During the whole sampling campaign, the shallow water temperature was continuously recorded with the underwater observatory located at the Old Pier in approximately 11 m depth [15].

2.2. Sampling of Fish Eggs. Sampling at Kb3 was conducted using a standard CalCOFI plankton net with a diameter of 113 cm and mesh size of 500 μm . A smaller plankton net with a diameter of 67 cm was used at the other two sampling sites as sampling was conducted from a smaller boat that did not allow for deployment of the large CalCOFI net.

At the sampling site Kb3, each sampling comprised one vertical and one horizontal plankton net haul. Vertical net hauls were performed from 50 to 0 m with an average speed of 1 $\text{m}\cdot\text{s}^{-1}$. The horizontal hauls were towed for 5 min at a speed of 1.5–2 km at approximately 1 m depth. Sampling at Brandal and along the transect between the Old Pier and the Ny-Ålesund harbour comprised of four horizontal net hauls, towed for 5 min at a depth of approximately 1 m. All plankton samples were visually checked for fish eggs and larvae. Before examining the samples under a dissecting microscope, fish larvae were removed and transferred to a Petri dish that was placed on a bed of crushed ice to keep it cool. Fish eggs were removed from the sample and stored in 96% ethanol at -20°C . If possible, representative images of all fish eggs per sample were taken, and if more than 20 eggs were caught, a random subsample of images was taken.

2.3. Fish Egg Identification. Fish eggs were identified to the species using morphological characteristics [9, 10]. Eggs of uncertain origin were photographed for further analysis.

3. Results

3.1. Pelagic Eggs. A total of 182 eggs of different fish species were caught over the entire sampling period entirely at the sampling site Kb3. The first fish eggs were found on 15th May, and the last eggs were found in late June. Four eggs were visually identified as *H. platessoides*. Although detailed information about egg stages was not obtained in this study, the analysis of the egg images suggests that only later stage eggs (stages 3 and 4) of the long rough dab were found (following egg staging criteria of [16]).

These eggs were only found in vertical and horizontal tows at the sampling site Kb3, but not in the shallow water zone. Two eggs were found on 19th May, another on 28th May, and the last one on 5 June 2020. After that date, no eggs of *H. platessoides* and from mid-June onwards none of any other fish species were caught, either at the pelagic or at the shallow water sampling site.

3.2. Water Temperatures. During the sampling period, the water temperature in the shallow water zone (<10 m) increased continuously from -0.8°C (01 May 2020, 11 m depth) to 5.6°C (16 July 2020, 11 m depth). In mid-May, the water temperature increased above 0°C .

The change from negative to positive degree Celsius values in 2020 was later compared to previous years, when it was often observed from March to early April. The maximum temperatures in 2020 increased to 8°C in early August which were the highest measured shallow water temperatures in that area since 2013 [15].

4. Discussion

Little is known about the occurrence and distribution of the long rough dab in the fjords of Svalbard. The eggs found in Kongsfjorden in this study did not confirm whether spawning occurred within the fjord or on the west Spitsbergen shelf. According to Walsh [7, 8], the distribution of eggs and larvae is mainly affected by local currents and physical oceanographic processes of the water masses. These currents and the local wind systems are also the main driver for advective processes between Kongsfjorden and the neighbouring shelf [17]. Therefore, the currents flowing into the mouth of Kongsfjorden may have transported the eggs into the fjord. The local hydrographic regime in combination with weather conditions such as wind directions from the west Spitsbergen shelf into the fjord could explain why the initial observation of eggs was exclusively in the centre of Kongsfjorden (the sampling station Kb3) rather than at the sampling sites close to the shore and in shallow waters.

Therefore, we assume that eggs were introduced into the fjord due to the hydrographic regime and local wind systems.

Alternatively, the long rough dab might have spawned within the inner parts of the fjord itself finding suitable spawning and settlement conditions in Kongsfjorden. Based on ecological indicators, the authors in [18] divided Kongsfjorden into four zones, two outer and two inner fjord zones, of which the two inner ones are least affected by advection processes [17]. Considering the development time of long rough dab eggs (11–14 days at 4°C [11]), the sampled eggs have an approximate age of at most 10 days, which could indicate spawning in the inner part of the fjord rather than being advected from the west Spitsbergen shelf.

The 0-group long rough dab could not be found in the deeper parts of Kongsfjorden so far, but small numbers of the 0 group were recorded off the west coast during surveys from 1985 to 1991 [7]. According to Walsh [7], small populations inhabit the fjords on the west coast of Svalbard, but the literature reporting catches within Svalbard fjords is sparse. Hop et al. [18], however, described the long rough dab as common for the deep-water regions of Kongsfjorden, particularly for their “transitional zone” between the inner and outer fjord close to which the outer boundary station Kb3 is situated. In general, the west coast of Svalbard and its adjacent fjords are generally not often surveyed for ichthyoplankton because of their isolated location. Available information about the egg and larval distribution is, thus, very limited.

Milinsky [5] inferred from seasonal catch distributions that in the Barents Sea, the long rough dab undertakes periodic spawning migrations once the adult stage is reached. More recent publications, however, indicate that this may not be the case [4]. Adult individuals are distributed north of the Svalbard bank and in coastal waters off western Svalbard, and there appears to be a distributional overlap between juveniles and adults [2]. Walsh [8] also mentioned that migration can be a response to temperature changes. In Kongsfjorden, advective processes within the hydrographic regime like the warm water inflow vary among years [19] and show very particular temperature characteristics in 2020

(own observation), with long-lasting low temperatures at the beginning of the year and high temperatures during summer compared to previous years.

Over recent years (2012–2019), a mean annual increase of 0.17°C in the shallow water masses (<12 m) has been observed [13]. In the shallow layers (up to 12 m), temperatures below 0°C were observed until May. In contrast, 2020 also had one of the highest maximum temperatures (8°C) observed in the last 8 years [13]. The long rough dab can tolerate a temperature range between –1.3°C and 5°C in the Barents Sea [1], and larvae were observed within near-surface temperature ranges of 3°C–5°C in May and 5°C–7°C in June/July [7]. These temperatures are in accordance with the temperatures recorded from May to July 2020 in the shallow water zone of Kongsfjorden. Ongoing changes of Kongsfjorden's temperature regime could make this fjord, like other Atlantic-influenced fjords of Svalbard more suitable for early life stages of boreo-arctic species like the long rough dab. A changing hydrographic regime towards warmer waters could affect the distribution and dispersion of eggs, and temperature could influence survival and vertical migration patterns. The observation of long rough dab eggs could be a result of a fluctuating temperature regime which affects the spawning success within Svalbard fjords. In 2020, it seems most likely that eggs have been advected into the fjord where larvae find an environment suitable for survival. It cannot be postulated with certainty that eggs were absent in the fjord before, but our observation do confirm their presence nowadays. Whether this observation indicates an existing local spawning population or results from adapted changes in spawning behaviour or is just a unique occurrence due to short-term changes in the temperature regime remains unclear.

Future ichthyoplanktonic surveys in the Kongsfjorden system could help broaden the knowledge about the distribution of the long rough dab in a warming Arctic. A comparative analysis between the deeper areas of the fjord and the shallow water zone should be conducted to understand the role of the different habitats for this species.

In addition, the presented observation of long rough dab eggs might help to improve the knowledge about the egg distribution in Svalbard fjords and create a baseline in the future understanding of the distribution pattern due to increasing water temperatures.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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