Conducting a mackerel egg survey to determine the size of the mackerel spawning biomass: how do we do this?

Every three years, a mackerel egg survey is conducted in the Atlantic Ocean to determine the size of the mackerel spawning biomass. The data is used by ICES (International Council for the Exploration of the Sea) for annual stock estimates and catch advice. Wageningen Marine Research (WMR) conducts this mackerel egg survey in collaboration with other European institutes, partly in collaboration with the pelagic fishing sector. The theory is simple: count the number of eggs in the sea and divide this by the average number of eggs laid by a female mackerel. By doing this, you can estimate how many female mackerel are swimming in the ocean, and thus how large the spawning biomass of mackerel is. But how exactly do you do this and how do you recognise a mackerel egg?

Why conduct a mackerel egg survey?

This survey was first conducted by England and France in 1977. Until then, there was no research available that could serve as a basis for estimating mackerel stocks. At that time, acoustic research was still in its infancy. It was also difficult to set up a stock survey for a fish stock that is dispersed over a huge area (see Figure 1) and also makes long migrations throughout the year.

Figure 1. The area where mackerel occurs is shown in blue and the areas where mackerel reproduces are shown in red (Berge et al., 2015).

It was therefore decided to conduct an egg survey during the spawning season when the mackerel are located west of the United Kingdom and France. The North Sea has been included in the sampling since 1980. The time series of the survey has therefore been running since 1977 and is used to track developments in the mackerel stock over time. The egg survey is the only survey that samples the entire spawning area throughout the spawning season for both the North Atlantic Ocean and the North Sea. It is also the only survey that provides information on the reproductive biology of mackerel.

How do you conduct an egg survey?

There are various methods for determining stock size using an egg survey, but all methods are based on the same theory: count the number of eggs in the sea and divide that by the average number of eggs laid by a female. You can then estimate the number of females that laid the eggs. Next, determine the ratio between males and females (for mackerel this is 1:1, so for every female there is one male) and you will have an estimate of the spawning biomass.

For mackerel, the Annual Egg Production Method (AEPM) has been chosen. For this AEPM, the entire spawning area must be sampled throughout the spawning season according to a specific route. The mackerel spawning area used to extend from Portugal to Scotland in a north-south direction, and from Rockall to the north-western European coast in an east-west direction. Since the last decade, the spawning area has expanded from Portugal to Iceland and eastwards to the Hatton Bank (see Figure 2). Mackerel prefer a water temperature of around 12°C for spawning. In all likelihood, this expansion of the spawning area is partly due to the warming of the sea water.

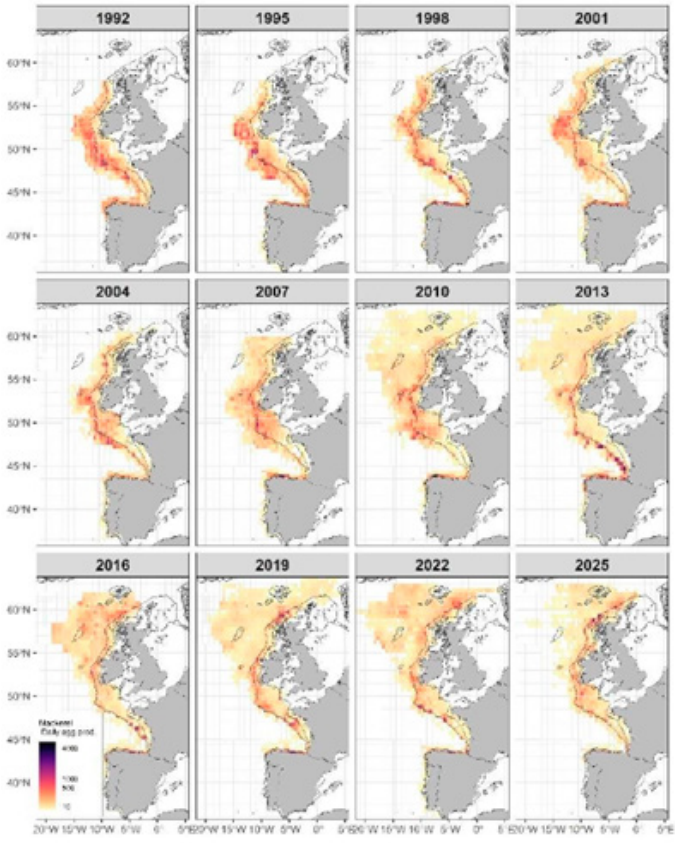

Figure 2. Annual distribution of mackerel eggs for the various surveys from 1992 to 2025. The maps show the annual distribution of daily mackerel egg production (stage I eggs per square metre per day) per research year and rectangle. The darker the colour, the more eggs were found at that location. The figure clearly shows that in recent years, the area where mackerel eggs are found has increased considerably (ICES WGMEGS report 2025 not yet published).

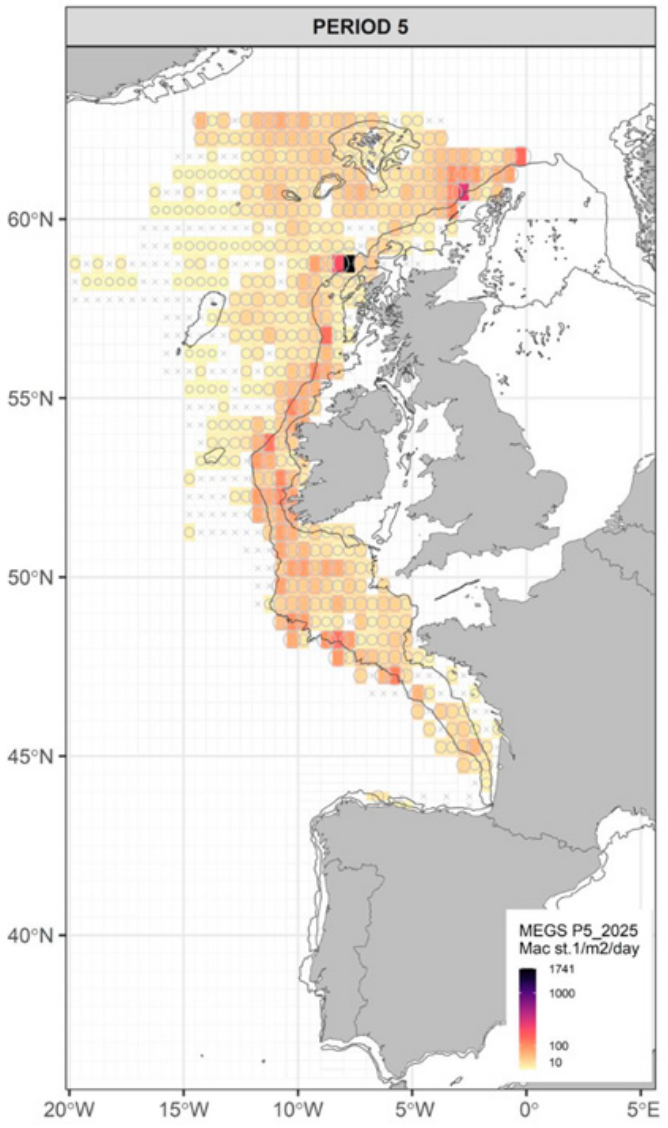

Figure 3. Egg production per m2 per day per half ICES quadrant for period 5 during the 2025 survey. The darker the colour, the more eggs were found at this location. A cross means that samples were taken but no eggs were found (ICES WGMEGS report 2025 not yet published).

Mackerel spawn from early February to late July. During this period, sampling must be carried out continuously. The survey is divided into six periods corresponding to the months. The spawning area is divided into sections, so-called “half ICES quadrants” are laid over the spawning area. A half ICES quadrant is a square measuring 0.5 degrees east longitude and 0.5 degrees north latitude. One station is sampled per half ICES quadrant (see Figure 3). As this area is constantly expanding, it is taking more and more time to carry out the mackerel egg survey. Several countries and research institutes are therefore involved in conducting the research.

How are fish eggs sampled?

Mackerel eggs are 1.2 mm in size. Therefore, a fine-mesh net is required to sample these eggs. High-speed plankton gear is used to sample the eggs. Wageningen Marine Research uses a Gulf VII plankton net (see Figure 4).

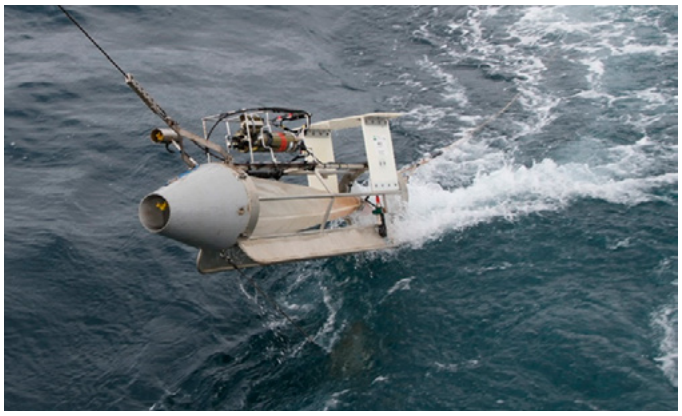

Figure 4: Gulf VII plankton net just after it has been pulled out of the water. The grey conical nose cone with net can be seen at the front. The equipment for measuring salinity, temperature and depth is located in the middle of the frame. At the end of the gear is a white wing that provides stability.

The Gulf VII is an open aluminium frame measuring 2 metres in length with a conical nose cone at the front and a plastic wing at the rear. A plankton net with a mesh size of 280 µm (0.280 mm) is attached to the frame. The nose cone contains a flow meter that measures how many litres of water are filtered during a haul. The frame is equipped with a sensor to monitor the temperature and salinity of the water. An altimeter (a meter that measures the distance between the frame and the seabed) is also attached to the sensor so that the plankton net can be tracked in the water during a haul. This is important because the plankton net is used to perform a so-called oblique haul, which means that the plankton net is pulled through the water at a speed of 4 knots in a V-shape (see Figure 5). Each metre of water is sampled for 1 minute when lowering the net and again for 1 minute when hauling it in. The net is lowered to a depth of 200 metres, unless the depth is less than 200 metres. In that case, the net is lowered to 5 metres above the seabed. Accurate measurement of the net in the water column is essential because the plankton net must not touch the seabed, as this would damage the equipment.

Mackerel often spawn in deeper water and after fertilisation the eggs float upwards. Most eggs are found at a depth of around 20 metres. In order to sample the newly spawned eggs, it is therefore very important to sample the entire water column (maximum depth of 200 metres). The development of the larvae in the eggs depends on the water temperature. The higher the temperature, the faster the larvae develop. At a water temperature of 12°C, it takes about a week for the larvae to hatch.

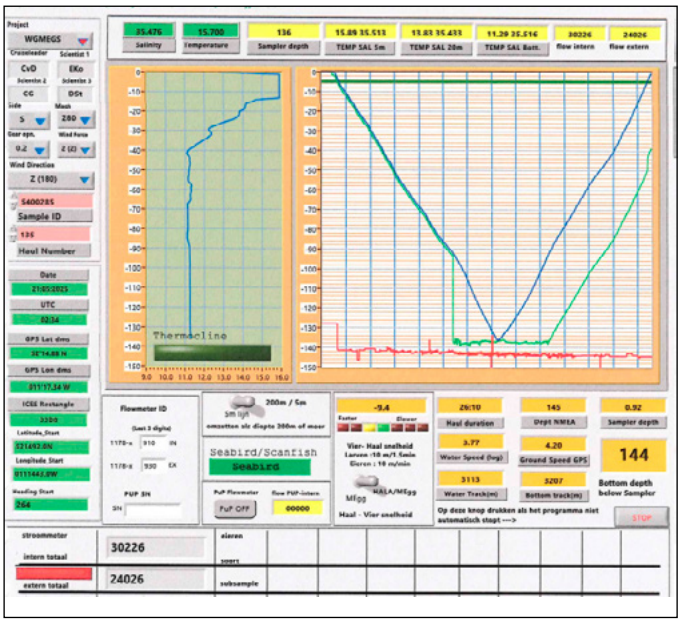

Figure 5. Illustration of a double oblique pull in the Labview Gulf programme. Left: The blue line shows the temperature in the water column. On the left side of the graph, you can see the depth, and at the bottom, the temperature. From approximately 12 metres, you can see the temperature drop sharply. Right: The blue line shows the depth of the plankton gear, the red line shows the seabed, and the light green line shows the "safety line" 5 metres above the seabed. The upper dark green line indicates 5 metres below the water surface. At shallow stations, the gear must be lowered to the seabed again when this line is reached.

When the plankton net is brought back on board after a haul, the sample is immediately fixed in formalin. Fixation in formalin ensures that the fish eggs are preserved for a long time. Fish eggs are transparent, which makes fresh eggs difficult to see. After 24 hours of fixation, the eggs become opaque and therefore more visible. After 24 hours of fixation, all eggs are removed from the sample (Figure 6).

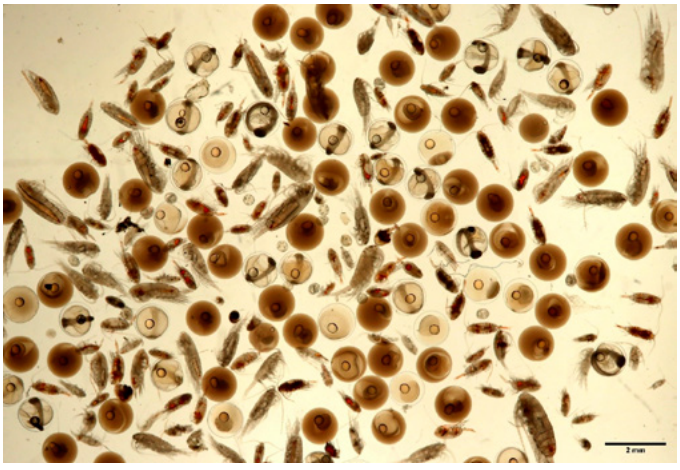

Figure 6. The round balls are mackerel eggs in a plankton sample. In addition to mackerel eggs, copepods can also be seen. This sample also shows mackerel eggs at various stages of development. The darker mackerel eggs are eggs that have just been fertilised, while the lighter eggs containing a larva are already several days old.

In addition to mackerel, many other fish species spawn in the spawning area. Mackerel eggs can be distinguished on the basis of egg diameter, the presence or absence of oil droplets, the colour of the oil droplets, the segmentation (presence or absence of a structure) of the yolk sac and the space between the yolk sac and the egg membrane. Mackerel eggs are 1.2 mm in size, have 1 oil droplet of 0.2 mm, no segmentation in the yolk sac and a small space between the yolk sac and egg membrane (see Figure 7).

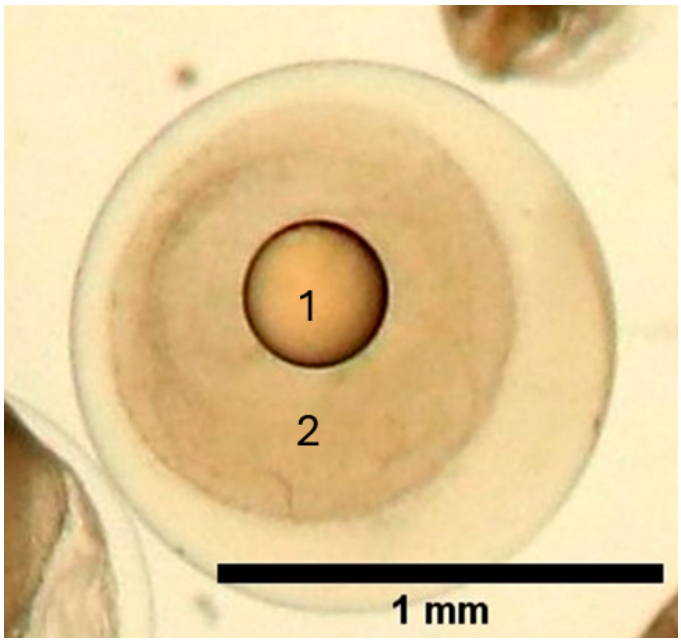

Figure 7. This photograph shows a mackerel egg. Number 1 indicates the oil drop and number 2 indicates the yolk sac.

There are five distinct stages of development in mackerel eggs. The first stage of development is when the egg has just left the female and has been fertilised, and the last stage is when the larva is about to hatch. These stages are important because only the first two stages are taken into account, as it is assumed that mortality is negligible at this point. A sample can sometimes contain 10,000 fish eggs. It is far too much work to count all these eggs and determine the species of each one. Therefore, this is only done in parts, by taking a sub-sample from the sample. At least 100 mackerel eggs must be measured from each sample. In addition, the stage of each egg must be indicated.

The total number of eggs in a sample is divided by the volume of filtered water to obtain the number of eggs per cubic metre. This is then multiplied by the water depth, as this depth varies per haul, to give the number of eggs per square metre. All eggs per cubic metre per sample are added together and the sum gives an estimate of the total number of eggs spawned during the entire spawning period.

Determining the number of eggs laid by a female

Mackerel are batch spawners, which means that female mackerel lay eggs several times during a season. In order to determine how many eggs a female can lay in total per season, it is important that the female fish are collected before they have laid their first batch of eggs. That is why, in addition to the plankton trawls during the survey, a number of fish trawls are also carried out with a pelagic fishing net to catch mackerel that are about to spawn. In the past, however, it proved difficult to collect samples of females that had not yet spawned at all that season. This is because the timing of the survey is mainly focused on being in the area when eggs are spawned and not on catching mackerel that have not yet spawned.

Commercial pelagic fishing often targets mackerel in the spring. Since the 2022 survey, the sector has also been actively involved in sampling. By sending a researcher on board a commercial vessel, significantly more samples can be collected from mackerel that have not yet spawned, which can be used for analysis.

The methods used to process a fishing haul sample on board a research vessel and a commercial fishing vessel differ slightly, but follow roughly the same steps. At least 50 mackerel are sampled from a fish haul. The length, weight, sex, stage of development of the roe (maturity) and age of the mackerel are determined. The roe of females at the right stage are weighed and several small pipette samples are taken from the roe (see Figure 8). Pipette samples are accurate small quantities of egg cells (oocytes) that are sucked out of the roe. These roe samples are also fixed in formalin and only processed further in the WMR laboratory in IJmuiden.

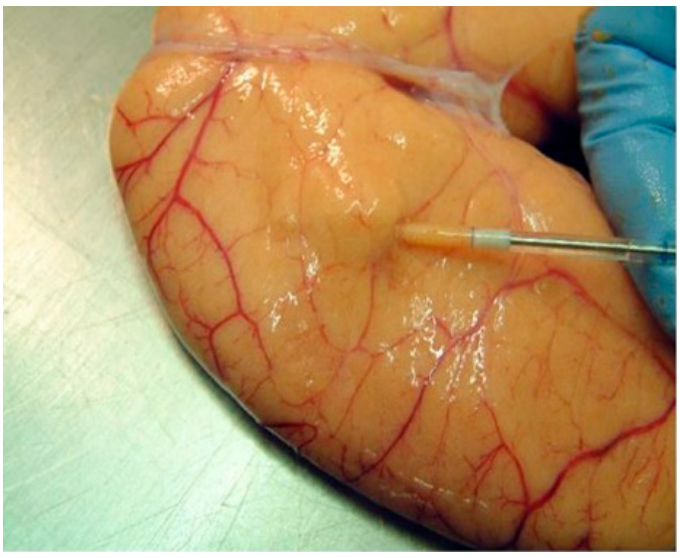

Figure 8: This photo shows a mackerel roe with a pipette inserted into it. The pipette has a plunger that can be used to take an accurate weight sample from the roe.

The pipette sample has a specific weight, and you can count the number of oocytes (eggs in the roe) in it. Using the total weight of the roe and the weight of the sample taken from the roe, for which you know how many eggs there are, you can calculate the total number of eggs in the roe. If the female has not yet spawned that season, you will know how many eggs she can theoretically spawn. We call this potential fertility. To determine whether a female mackerel has already spawned, you can look at the roe with the naked eye, but to double-check, a screening is always carried out using photographs taken of a piece of tissue from the roe (see Figure 9). These clearly show whether there are any remains of spawned eggs. Oocytes are enclosed in a kind of membrane in the roe. When the oocyte leaves the roe (and has therefore spawned), this membrane (POF) remains in the roe for a while and is fairly easy to recognise. Put simply, roe containing POFs is no longer suitable for analysing potential fertility.

During the last two surveys in 2022 and 2025, data on the fertility of female mackerel was collected both on board the research vessel and on board a commercial fishing vessel (see Figure 10). This is a good example of how science and the sector work together to collect the best possible data. All information, from the eggs to the females, and from the various participating countries and institutes, will be merged at the end of the research period. All this data will then be used in the stock estimation models.

Berge, Jørgen & Heggland, Kristin & Lønne, Ole & Cottier, Finlo & Hop, Haakon & Gabrielsen, Geir & Nøttestad, Leif & Misund, Ole. (2015). First Records of Atlantic Mackerel (Scomber scombrus) from the Svalbard Archipelago, Norway, with Possible Explanations for the Extension of Its Distribution. Arctic. 68. 54-61. 10.14430/arctic4455.

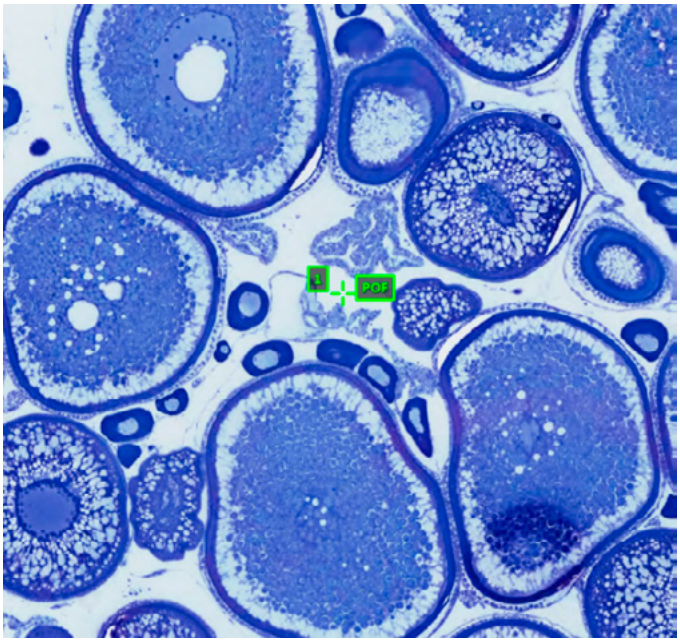

Figure 9. This is a photograph of a piece of tissue from the roe of a mackerel after histology. The round structures are oocytes (egg cells) and next to the green 1 is a somewhat messy structure. This is a membrane (POF) that remains after the oocyte has left the roe. This means that this mackerel has already spawned and is not suitable for the potential fertility analysis.

Figure 10. Samples are collected onboard a commercial ship.

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