The mechanization of Dutch mussel farming.

Two mussel growing techniques can be distinguished, namely, bottom culture and off-bottom culture.
In The Netherlands only bottom culture is practised, owing to the natural circumstances.
The mussels (Mytilus edulis L.) are reared on plots in the Waddenzee and the Oosterschelde (Eastern Scheldt) in the province of Zeeland. The farmers lease the growing plots from the government. The plots are planted with mussel seed, which the fisherman may fish from the natural seed beds once or twice a year during a fixed period.
The Netherlands is the biggest producer of bottom-grown mussels in the world. Its average annual production over the 1971-1975 period amounted to a hundred million kg. 70 p.c. of which came from the growing plots in the Waddenzee and approximately 30 p.c. from the Zeeland plots.
The world's biggest off-bottom producer and also the world's biggest mussel producer in general is Spain, having an average annual production of 110 million kg over the 1971-1975 period. The mussels are grown there on ropes, which hang down in the water. These ropes, up to about 10 metres long, on which the mussel seed is attached, are suspended from rafts in the inlets (Rias) in the Northwestern coast of Spain.

Another off-bottom technique is growing mussels on poles, the so-called polemussels or "Moules de bouchot". This method is used on the Atlantic coast of France. As a result the country's annual production averaged 35 million kg over the years 1971-1975.

Several variants of the off-bottom technique are to be found in various places in the world. The techniques used are determined by the natural circumstances under which mussel cultivation can be persued. In some developing countries in South East Asia and in India there is a growing interest and research is being carried out into the possibilities of producing proteins fit for human consumption by means of mussel cultivation. The mussel, being a marine animal, is extremely suitable for this purpose, because, provided the sea supplies enough nutrient matter in the form of phytoplankton, it converts this directly and efficiently into high-grade proteins edible for human beings.

Off-bottom culture is characterized by much manual labour. It hardly lends itself to mechanization. Mechanization can be more easily applied to bottom culture. Consequently, growing and processing, i.e. preparing the mussels for human consumption, has been highly mechanized in the Dutch mussel growing industry.

As a result of this mechanization the modern mussel vessels can catch as much as 30 to 40 tons an hour from a full plot. In 1977 the fleet totalled 86 ships with an average propulsion power of 250 h.p. and an average carrying capacity of 70 tons, including some new ships with a carrying capacity of 130 tons.
The maximum power officially allowed is 320 h.p.
The vessels have an average crew of three men and are equipped with 4 dredges, each of which measures 1.90 metres across. It is the maximum size officially allowed.

The dealers too, can prepare large quantities of mussels for consumption in a short period, owing to highly mechanized processing.
The mechanization of to-day's mussel farming industry is attended with rough handling and therefore it has its reverse as well, as it impairs quality and particularly keepability. It is necessary that the mussels are sold alive to the consumer. If he buys a certain amount of mussels and happens to find a number of shells open or, at its worst, mussels already dead, the whole lot is hardly fit for consumption any more. Gaping and subsequent dying is caused by the rough handling the mussel undergoes due to processing and transport from production bed to consumer. This does not necessarily result in visible shell damage, but dropping and bumping inflict internal injuries on the fish. This damage appears first of all from loss of moisture. The moisture the mussel normally has within the shell cavity accounts for some 30 p.c. of its total weight. Sufficient moisture within the shell prevents desiccation of the fish. If the mussel undergoes rough handling, it will suffer internal damage and lose moisture, resulting in loss of keepability. Even if the mussel reaches the consumer with its shell still closed, its freshness and taste will have deteriorated, owing to loss of moisture.
In order to ensure a good taste of the flesh the mussels should be stewed in their own juice. It may be stated that high mechanization of the mussel farming industry has impaired mussel quality as regards freshness and taste. In this lecture the processing method and its effects on the mussels with respect to loss of keepability, the causes of shell breakage, and the removal of tare will be elucidated.

Mussel processing

Processing is carried out by the dealers in order to prepare the mussels arriving from the storage beds for consumption. Processing means that:

1. the mussels are declustered.
2. their exteriors are cleansed from growths like barnacles and bryozoes.
3. the tare among the mussels is removed.
4. they are weighed and bagged for dispatch.

This slide shows ascheme of the processing line, which is also called a cleansing installation.
The purpose and technical details of the cleansing installation will be treated in the order in which the mussels pass through it.

1. Mussel supply

A grab unloads the mussels, which are shipped by a mussel vessel from storage plots, into the hopper that is attached to the declusterer.

2. Declusterer

It is used to separate clustered mussels. After this the tare among them can be removed more easily.
The declusterer consists of a cylindrical tube with an internal diameter of some 500 millimetres and a length of some 1500 millimetres. An axle with long steel knives rotates inside.
These knives have been mounted spiral-wise on it, so that they force the mussels from the hopper through the tube. This propulsion can also be regulated by administering water at the beginning of the tube parallel to the axle.
Declustering is attained because the knives cut through the mussel clusters. This effect occurs when the tube is completely full of mussels so that friction against the walls of the tube prevents them from turning around at the same speed as the knives.
The mussels remain in the declusterer for approximately 90 seconds, the exact duration depending on the amount of water injected, the grade of clustering, and the number of revolutions the engine makes.

3. The washer

The washer removes the tare among the mussels, such as adhering sand and silt, shell debris, and empty shells. The shells are cleansed from growths and barnacles. The washer is a cage-like rotating cylinder consisting of a series of iron rings.

It is about 700 millimetres in diameter and about 3 metres long.
Through a perforated tube running parallel to it water is injected on the mussels inside. The distance between the rings determines the size of the tare that is washed away.

The flow of mussels is ensured because the washer is inclined at a slight angle.

4. Blower

The blower removes empty shells and seaweed from among the mussels. A blower under a wire-gauze conveyor belt sends an air current through the mussels on it. Thus light-weight tare is blown away and carried off sideways through a funnel.

5. Sorter

Remaining tare like mussels with broken shells, dead ones, starfish, empty oyster-shells and stones are picked out by hand.

6. Weighing apparatus and hopper

At the end of the sorter the mussels are prepared for transport and the desired quantities are weighed and put into sacks.
If the mussels are only slightly clustered and the tare rate is normal, approximately 10,000 kg of mussels, i.e. 300 sacks containing 33 kg, can be packed per hour by means of the above-mentioned installation, two sorters and a weighing installation each.
Approximately 14 persons are required for this job, namely, a skipper and a crane-driver for unloading the vessel, 8 sorters, and 4 packers.

The effects of mechanical processing

To improve handling and processing and consequently the quality of the mussels 14 lots of mussels were sampled from September 26th to November 14th 1977.
The aim was to check the influence of fishing and processing on the mussels conveyed from the storage plots regarding keepability, shell breakage, and removal of tare.
During this particular period a reasonably objective picture of the quality of processed mussels could be obtained, because the product shipped from the growing beds was ideal for processing. This "standard" mussel is a three-year-old with a firm shell; it is unclustered or hardly clustered, and its average cooked meat content is approximately 26 p.c.
During that period the water temperature of the plots averaged 13 degrees centigrade and the air temperature to which the mussels were exposed for survival tests averaged 13 degrees centigrade as well.
The data gathered from this survey have been supplemented further with data from previous research into the processing of three-year-old mussels, carried out under comparable circumstances.

This slide schematically shows the processing of mussels from plot up to and including packing and the points where the samples were taken.

The next slide shows the increasing mortality rate of mussels exposed to the air for 72 hours. Such a keeping period roughly corresponds with the duration of transportation and stay of export mussels at the wholesalers and retailers.

Gaping and failure to close after an external stimulus was taken as an indication for mortality.

The diagram shows that the loss of keepability, measured in mortality rate, increases from 1.5 to 23 p.c. between plot and sack.

The next slide shows shell breakage rates in the successive stages of processing.

The total breakage rate is 8 p.c. As 2 p.c. of severely damaged mussels are picked out, the mussels are packed with a breakage rate of 6 p.c. This breakage consists mainly of hardly visible hairline cracks in the shell.

The total damage done to the mussels, which consists of accelerated mortality and shell breakage, can be further illustrated on the next slide, which shows the diagrams of the two preceeding slides.

Immediately after arrival from the growing plots the mortality rate is 1.5 p.c. when the mussels are exposed to the air and the breakage rate is nil.

Fishing with dredges and unloading them into the hold accounts for 3.5 p.c. mortality and 3.5 p.c. shell breakage.

Unloading them into the hopper by means of a grab causes a mortality rate of 2 p.c. and a breakage rate of 9.5 p.c.

The death-rate in the declusterer is 1 p.c. This relatively low percentage is due to slight clustering, which prevents injuries caused by tearing of byssal attachments. Moreover, the mussel do not drop and bump in the declusterer.

A 3 p.c. breakage rate is rather high. It consists predominantly of severe shell breakage incurred between the knives and the cylindrical breaker wall.

As a result of abrasion the opening between knives and wall widens, causing an increase of the number of crushed mussels.

The washer accounts for 10 p.c. of the mortalities, which is nearly half the loss of keepability. Time measurements have shown that at a rate of 30 revolutions per minute the mussels stay in this washer, which is 3 metres long and has a diameter of 700 millimeters, for 90 seconds on average.

During this period the mussels hit each other quite a few times, which is demonstrated by the loud noise this machine produces when it is full of rolling and falling mussels. What remains is a mussel with a clean exterior, free from growths and with a bluish-black colour, which makes it commercially attractive, too.

The height of fall of the mussels in the washer is slight, the shell breakage rate is 1 p.c.

Of course, the blower does not cause damage; only the fall from the wire-gauze conveyor belt causes a 1 p.c. mortality rate.
Finally, when the mussels are weighed and packed, an extra mortality of 4 p.c. occurs as a result of the fall from the sorter into the weighing hopper and from this into the sack.

This slide shows that the loss of tare in the washer is 9 p.c., in the blower 2 p.c., and that 1 p.c. is picked out at the sorter.
Added to the 2 p.c. severely crushed mussels this makes a total tare rate of 3 p.c. picked out by hand.
The mussels' total stay in the processing line from the moment of entry into the declusterer up to and including packing lasts approximately 4 minutes.
It comprises approximately a 90 seconds' stay in the declusterer, a 90 seconds' stay in the washer, and a 60 seconds' passage from the wire-gauze conveyor belt into the sack.
These times are variable and depend on the amount of water injected into the mussel-filled declusterer, its size, the number of revolutions its engine makes, and the grade of clustering.

The total death-rate is an accumulation of mortalities owing to the successive stages the mussel passes through between cultivation plot and packing.
The diagrams on this slide, which you have already seen separately shows that the three major causes of loss of keepability are:

1) the washer (10 p.c.)
2) the mussels' falling from the sorter into the weighing hopper and from this into the sack (4 p.c.)
3) the technique of fishing with dredges, which are unloaded into the hold (3.5. p.c.)

The major causes of shell breakage are:

1) the fishing technique (3.5 p.c.)
2) the declusterer (3 p.c.)

Conclusion and discussion

Summarizing, from the research data it can be concluded that dredging, unloading mussels with a grab, and subsequent processing causes a 21.5 p.c. loss of keepability, measured by an accelerated mortality over 72 hours. The shell breakage rate is 8 p.c. As 2 p.c. of the broken shells are picked out, the mussels are finally packed with a 6 p.c. breakage rate.

On the basis of these date research will be focussed on improving the fishing and loading techniques of the mussel vessels, as well as on the declustering, washing, weighing, and packing of the mussels.
The project gives an idea of the damage done to the mussels by fishing and subsequent preparations to make them ready for consumptiom. It presents a instantaneous photograph, however. The figures may vary as a result of several factors, such as the population and the seasonal condition of the mussels watertemperature on the cultivation plot, temperature during processing, and the degree of clustering.
This research has been carried out in a period (from the end of September to mid November 1977) when the mussels are normally in optimum condition. Moreover, the sampled lot concerned three-year-old mussels with a firm shell, hardly clustered, and with an average cooked meat content of 26 p.c.
They were an ideal product for processing. Therefore, the figures do not present too unfavourable a picture. It is likely to be less favourable under different circumstances.
The results of the research dealt with here have shown that a considerable loss of keepability occurs, which is due to fishing and mechanical processing.
Less damage to the mussels can be achieved by an improvement of the machines in the processing line and by reducing dropping and bumping of mussels to a minimum. An improvement of musselquality after processing cannot be achieved by a technical development alone. The grower will also have to market a mussel that is more likely to survive processing. Optimum quality of mussels prepared for consumption can be achieved by an approach from two aspects, viz. from cultivation as well as from technique.

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To give you an impression how the Dutch musselindustry has been mechanised during the last 50 years. I will show you now a number of slides.

Slide 1

A so-called "Hoogaarts" a mussel vessel widely used in former years in the Dutch mussel farming.
Before the engine period, fishing was done by sailing and the dredges were hauled on board by manpower.
This vessel has already been equiped with a 30 hp engine, 2 booms, 2 dredges and a fishing winch driven by the engine.
The dredges measure 1 m across and the carrying capacity is about 15 tons.

Slide 2

Mussels intended for the fresh trade had been fished by hand in former years in the storage plots in the Oosterschelde.

Slide 3

In the past the clustered mussels were separated with a pair of scissors.

Slide 4

Modern musselvessel equiped with 4 dredges, a mechanical sowing installation and a carrying capacity of 130 tons.

Slide 5

One of the 4 dredges of a modern musselvessel.
The dredge is 1.90 m across and the capacity is 500 kg of mussels.

Slide 6

Musselvessel with a carrying capacity of a 100 tons.

Slide 7

Sorting, weighing and packing of mussels.

Slide 8

These are the Dutch mussels.

Figure 1: Mussel production line

1. Grab and hopper.
2. Breaker.
3. Washer.
4. Wire-gauze and blower.
5. Sorter.
6. Weighing apparatus and hopper.

Figure 2: Scheme of cleansing operation from storage plot to weighing and packing.

Sampling-point.	mortality rate
1. Farming plot.	1.5
2. Dredged + unloaded.	5
3. Hopper.	7
4. Declusterer (breaker)	8
5. Washer.	18
6. Blower.	19
7. Sorted and packed.	23

Figure 3:

Cumulative total of mortalities, as a result of dredging and mechanized sorting. Samples kept in the air during 72 hours' survival tests.
Average air temperature 13°C.
Samples taken at different stages of handling (between farming plot and packing).
Sampling period: September 26th-November 11th, 1977.
Mussels: 3 year old, slightly clustered, average cooked meat content 26 p.c.

Figure 4:

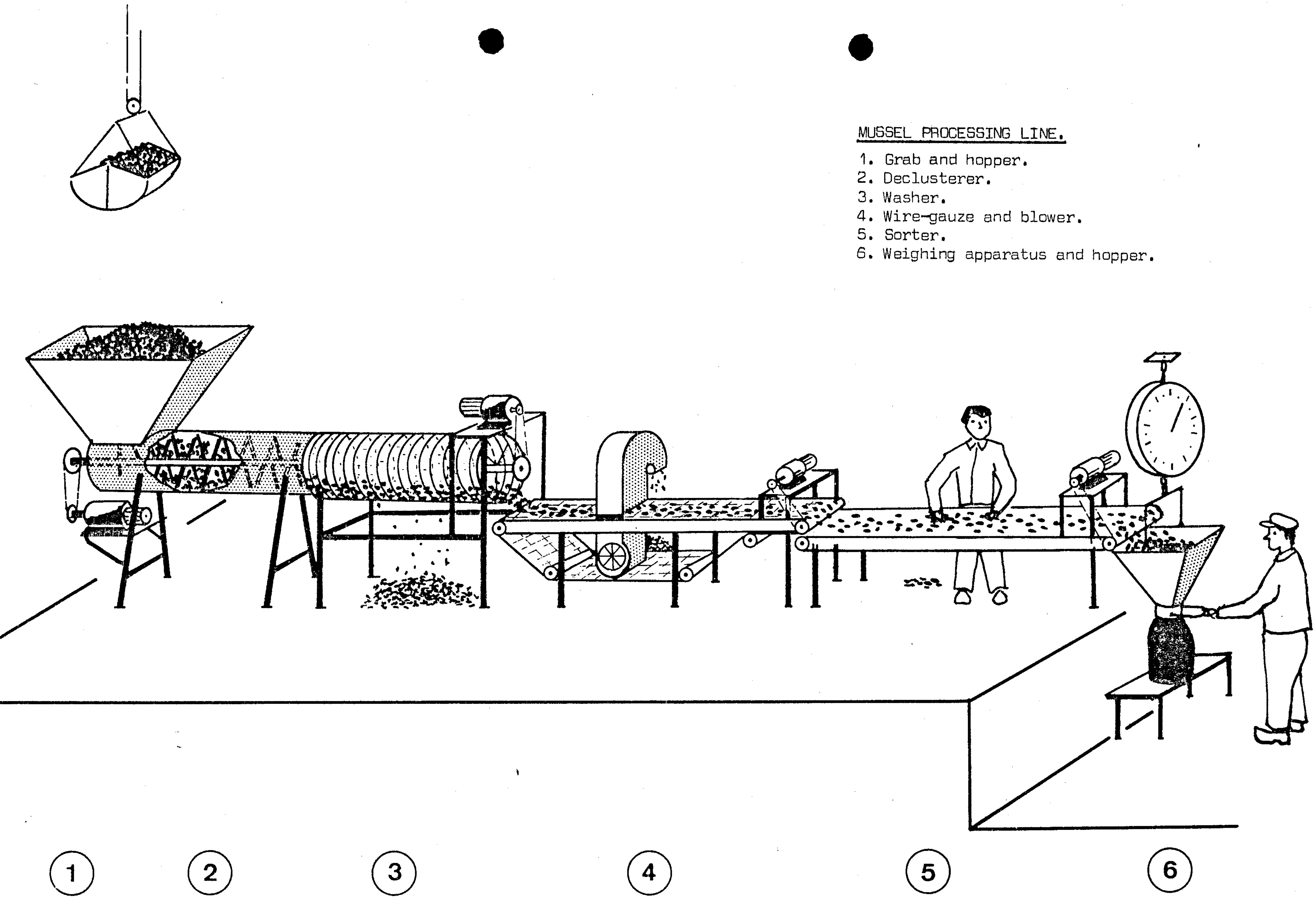
Shell damage to mussels as a result of dredging and mechanized sorting.
Samples taken at different stages of handling between farming plot and packing.
Mussels: 3 years old, slightly clustered, average cooked meat content 26 p.c.

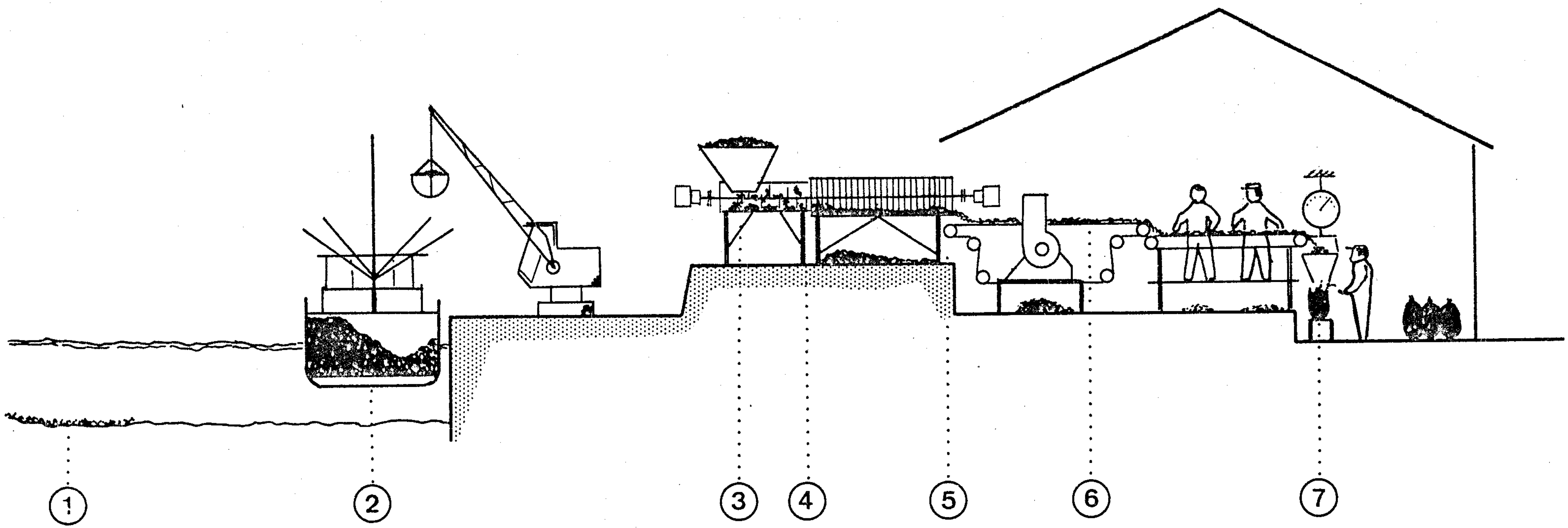
Figure 5:

Decline of tare among mussels, shell damage excluded, during mechanized handling in washer and blower, and after handpicking.
Sampling period: September 26th-November 11th, 1977.
Mussels: 3 years old, slightly clustered.
Average cooked meat content : 26 p.c.

MUSSEL PROCESSING LINE.

1. Grab and hopper.
2. Declusterer.
3. Washer.
4. Wire-gauze and blower.
5. Sorter.
6. Weighing apparatus and hopper.

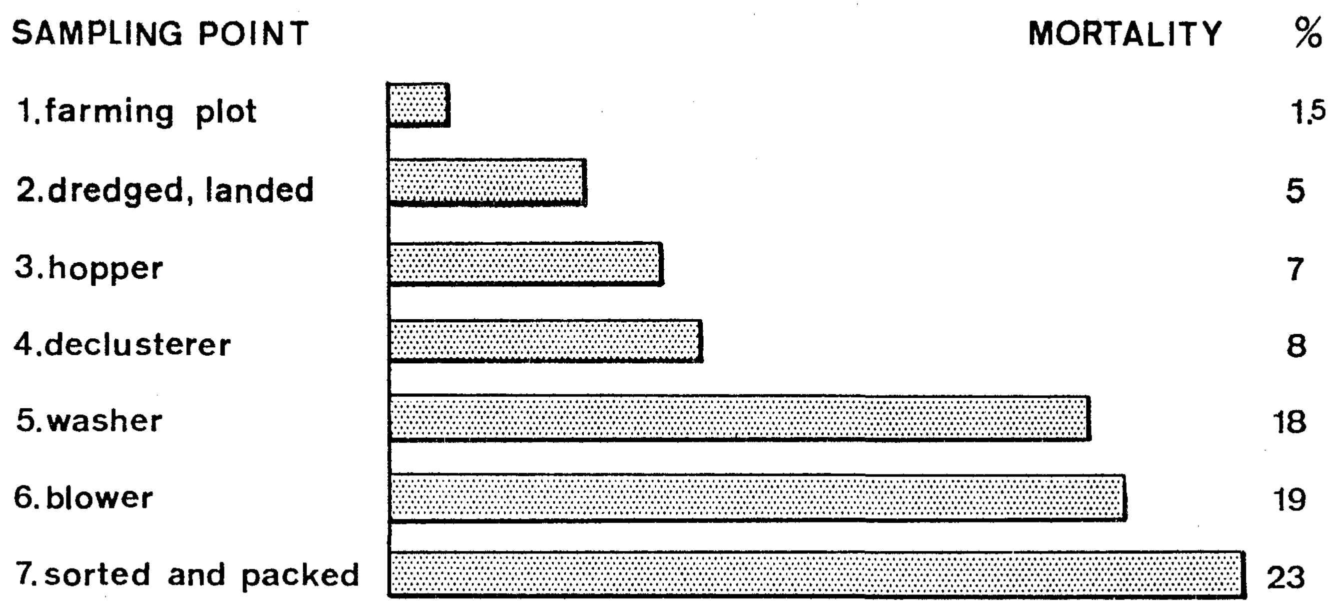




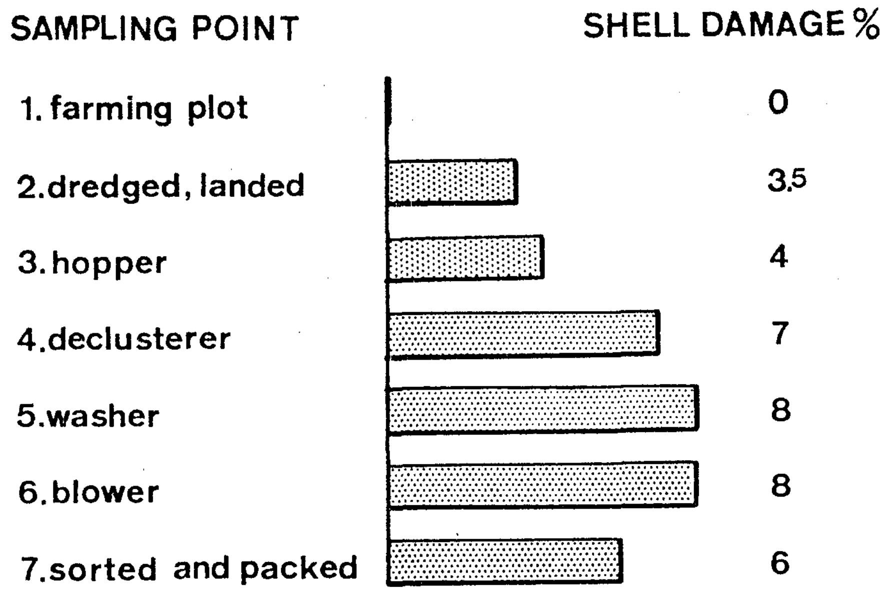
SCHEME OF PROCESSING OPERATION FROM STORAGE PLOT TO WEIGHING AND PACKING.

Sampling-points.

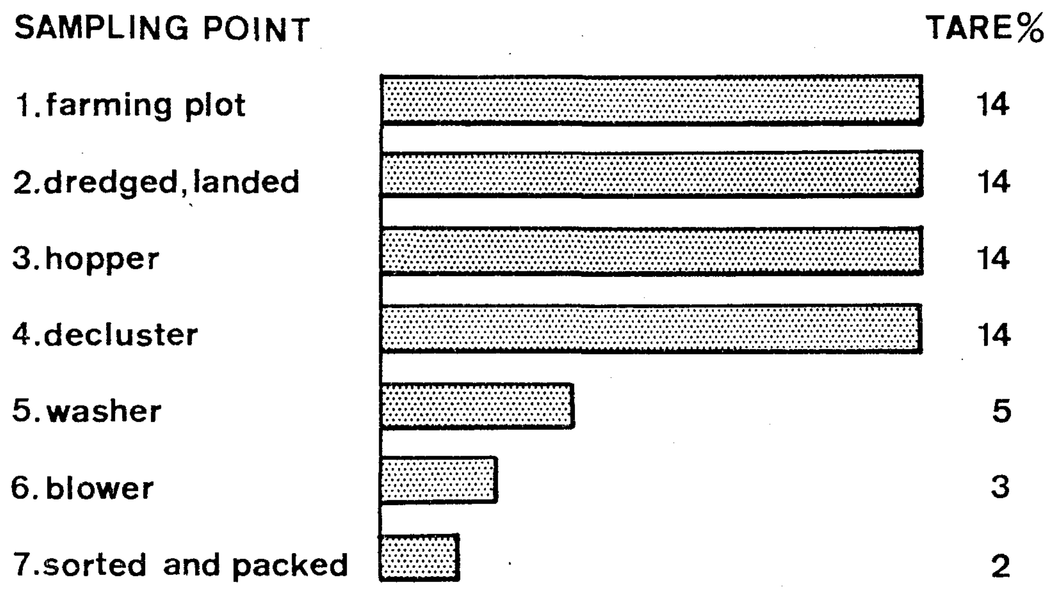
1. Farming plot.
2. Dredged and landed.
3. Hopper.
4. Declusterer.
5. Washer.
6. Blower.
7. Sorted and packed.



Cumulative mortality, as a result of dredging and mechanized sorting.
Samples kept in the air during 72 hours' survival tests.
Average air temperature 13°C.
Samples taken at different stages of handling (between farming plot and packing).
Sampling period: September 26th–November 11th, 1977.
Culture mussels: 3 years old, slightly clustered, average cooked meat content 26 p.c.



Cumulative shell damage to mussels as a result of dredging and mechanized sorting.
Samples taken at different stages of handling between farming plot and packing.
Culture mussels: 3 years old, slightly clustered, average cooked meat content 26 p.c.



Decline of tare among mussels, shell damage excluded, during mechanized handling in washer and blower, and after handpicking.
Sampling period: September 26th–November 11th, 1977.
Culture mussels, 3 years old, slightly clustered average cooked meat content 26 p.c.