The Edible crab

BIOLOGY – GRADING – HANDLING LIVE CRABS

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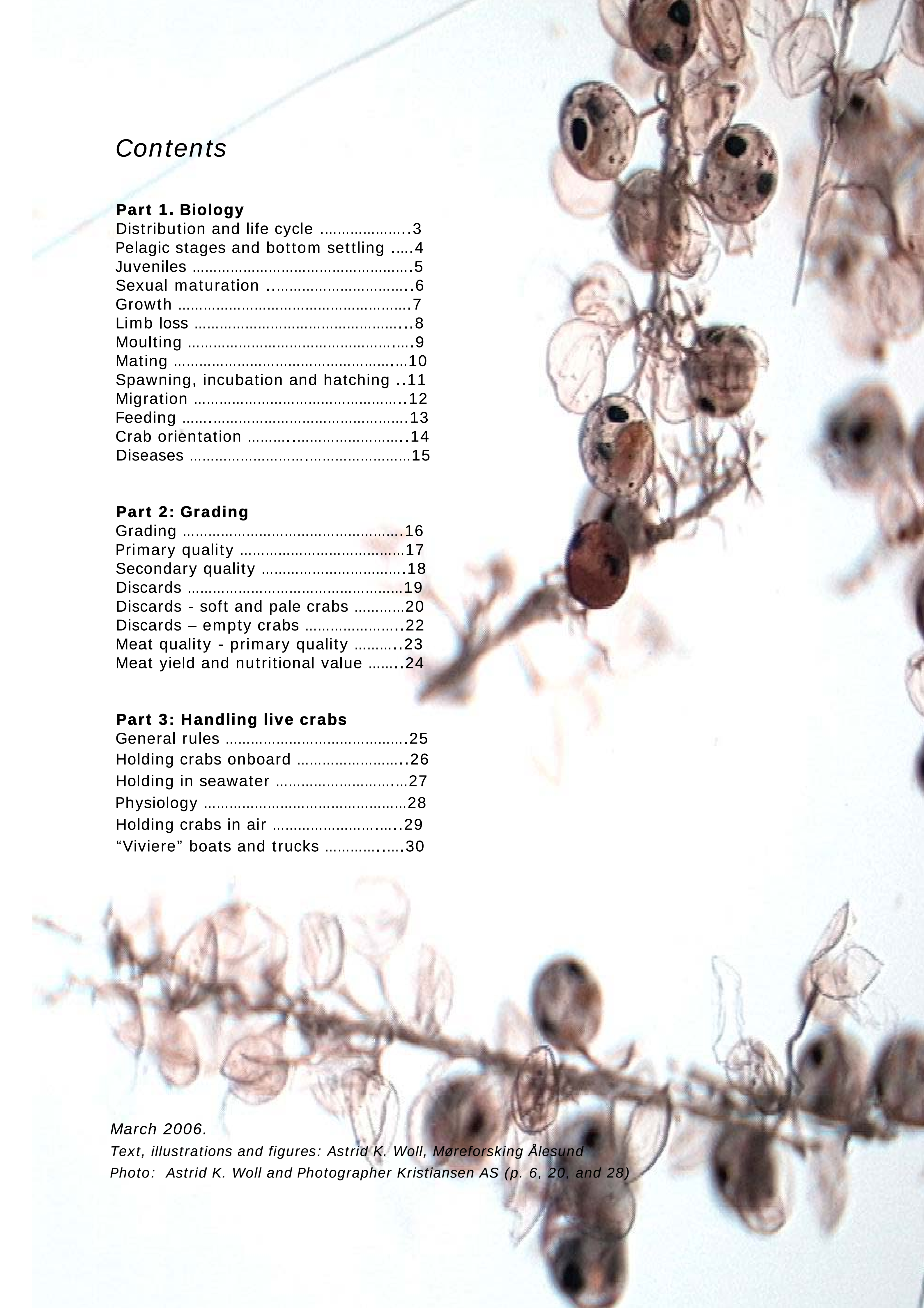

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Part 1. Biology

Distribution and life cycle

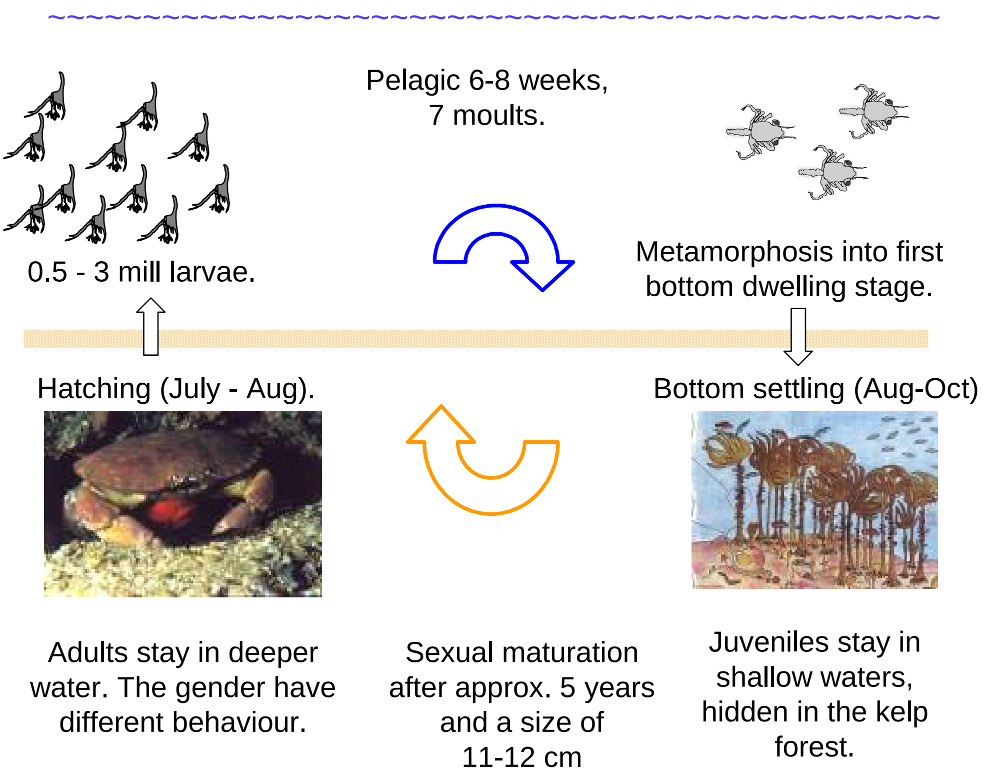
The edible crab is found along a wide stretch of marine coastal waters from Morocco (34°N) in northern Africa to Troms in Norway at about 70°N. The edible crab is also abundant in the Mediterranean Sea and Kattegat as well as in the seas around the Orkneys, Shetland and Faeroe Islands. Their main distribution is, however, in the English Channel and on large off-shore grounds on the continental shelf off the East coast of England, the Hebrides and Donegal, Ireland.

The lifecycle is divided into a short, pelagic stage and a long bottom dwelling stage. In the pelagic stage the larvae are dispersed by ocean currents. Their survival depends upon access to food and the number of predatory animals. A high survival rate may results in a strong year-class.

The larvae settle inshore in shallow water preferring a habitat consisting of a mosaic of bottom substrates such as gravel, pebbles, crevices and seaweed where they can find refuge. Juvenile crabs remain in such a habitat for the next 4 – 5 years.

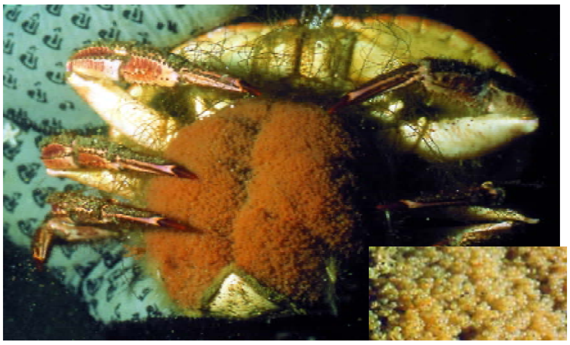
Adult crabs are mainly found at depths less than 50 m, but they do occur from the tidal zone to several hundred meters. Female crabs are mostly found on sandy bottoms with pebbles or larger stones where they can hide whereas male crabs seem to prefer rocky bottoms.

Peak season in the crab fishery is from August to November. Meat yield in crabs is at its highest at this time of the year. Most of the landings are made up of females as they gather on favourable grounds to feed and spawn



Pelagic stages and bottom settling

Newly hatched larvae are called prezoeae. This stage lasts for a few hours, after which the larvae moult into the first zoea stage. Larval development then goes through 7 planktonic zoea stages before the final metamorphosis into the first bottom dwelling juvenile stage. To some degree, larvae can choose what kind of bottom substrate they prefer to settle on. Newly settled juveniles are recorded along the Norwegian coast from September - October.



After 7-8 months attached to the hairy appendages on the abdomen, the eggs are ready for hatching.

The duration of each zoea stage depends on temperature and the availability of food. Zoea in the first stage can survive at temperatures as low as 7 degrees, but a minimum of 9 degrees is necessary for them to further develop. During the moulting process larvae are highly vulnerable to predation. The moulting process itself is also critical. It can fail and if so, the larvae will also die.

The larvae (zoea) are about 4 mm long, and have large eyes and long spines.

Long lateral spines on the posterior side of the larvae characterize the zoea stages. During metamorphosis the spines are reduced and the first bottom stage resembles a miniature crab with a carapace width of 2-3 mm. The claw tips are black while the colour of the shell may vary from brown to opaque white.

The hatching process has started, the shell bursts and the larvae are free.

Insert: First larvae stage (prezoeae) which lasts only a few hours.

Juveniles

Small immature crabs are called juveniles. These small crabs live in shallow water and are rarely found deeper than 12-15 meters. There are no observed gender differences in growth or behaviour patterns for juvenile crabs.

We are not sure how fast the juvenile crabs grow *in situ*. However, what we do know is that water temperature and food availability plays an important role in their growth rate.

One-year-old crab (carapace width 3.5 cm).

Observations in laboratory studies give an indication of how fast edible crabs can grow. During the first year juvenile crabs moult 5-9 times after settling, and can reach a carapace width up to 3 cm. In their second and third year they probably moult twice a year, and in the fourth and fifth year only once a year. The progression in the carapace width is approximately: 5 cm (2 yrs), 8 cm (3 yrs), 11 cm (4 yrs) and 12.5 cm (5 yrs).

An empty shell (carapace width 4 cm) may be mistaken for a live crab.

Kelp forests seem to be a suitable habitat for juvenile crabs. Here they are found in large numbers hidden in small cracks, under rocks, buried in sand or in piles of blue mussel shells.

Hidden between kelp (carapace width 4, 5 cm, 1 ½ -2 years).

Quickly burying in a pile of blue mussel shells (carapace width 6 cm, 2- 2 ½ years).

A power struggle between a green crab and an edible crab of equal size.

Sexual maturation

The crab becomes sexual mature at an age of 4-5 years and a size of 11-13 cm. After maturation gender characteristics become more pronounced during each moult.

Females

Female edible crabs have a broader abdomen than their male counterparts. Four pairs of hairy appendages are present on which the eggs are attached during spawning. The external genitals consist of a pair of large openings situated beneath the abdomen. The dorsal side of the carapace becomes more rounded during each moult giving more space for the internal eggs (roe).

Female crab. Above: Claws of moderate size and rounded carapace. Middle: Broad abdomen. Below: Four pairs of hairy appendages and the genital openings.

Males

The males have a narrow abdomen tightly fitted to the carapace. Abdominal appendages are present only on the first and second somites and they are modified to form copulatory organs. Sexual mature males have larger claws than juveniles and females and the carapace is flatter then their female counterparts.

Male crab. Above: Large claws and flatter carapace. Middle: Narrow abdomen tightly fit to the carapace. Below: Appendages modified to form copulatory organs.

Growth

The edible crab is covered with a hard and rigid outer shell made up of calcified chitin. This is cast at intervals and replaced by a larger one to give room for the crab to grow. This process is called moulting. Growth is a combination of the increase in size at a moult and the moult frequency. There are no structures in the new shell that give an indication of the age of the crab.

However, in the "eyestalk" of several crustaceans, traces of lipofucin are found. This substance accumulates throughout the entire life and the age can be determined by the quantity. The technique, however, requires great skill and expensive instruments and is therefore seldom used.

Tagging and recapture is the most common method used to assess the growth of crabs. At a given carapace width, the growth depends on the moult increment and the frequency of the moulting. For adult crabs the period between moulting may vary from 1 to 3 years.

Barnacles and calcareous tube dwelling bristle worms may settle on the carapace between moults. As the crabs shell gets older, the size of these animals gives an indication of the length of the intermoult period.

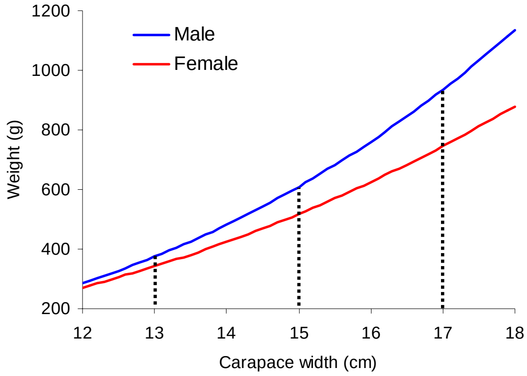
The calcareous tube dwelling bristle-worm Pomatoceros sp. is common on the crab shell.

The maximum age of the edible crab *in situ*, is probably about 20 years. The largest male crab recorded in Norway had a carapace width of 26.5 cm and the largest female was 22.5 cm.

Male, carapace width 24 cm, weight 2.5 kg.

Carapace width-live weight relation

Growth patterns for male crabs change after maturation. For instance, the claws grow relatively faster than the rest of the body. This is why mature males weigh more than females at the same carapace width. At a size of 13 cm, male crabs weigh on average 370 g compared to females 340 g, at 15 cm males weigh 610 grams compared to females 520 grams, and at 17 cm males and females weigh 940 and 750 grams, respectively.



Carapace width-live weight relation for adult female and male crabs.

Limb loss and self-amputation (autotomy)

If roughly handled, crabs may lose chelae or walking appendages by self-amputation, i.e. the crabs cast off limbs at random, those being held or limbs being injured. This may also happen when the crab becomes stressed such as during sudden temperature changes or exposure to an unfavourable environment.

The self-amputation takes place along the thin groove or fracture plane present at the base of each limb. The plane is covered with a thin membrane perforated by a small hole where blood flows. A short time after self-amputation the blood coagulates around this hole forming a clot. After a few days the membrane becomes brown or black.

A light membrane which covers the fraction plane indicates a recent loss while a darker membrane indicates an older loss, probably after a day or two.

A small papilla may appear beneath the membrane where legs or claws are lost. This is the beginning of a new leg. The papillae either stimulate or prevent a new moult depending on which intermoult stage the crab is in the moult cycle.

Two to three moults are necessary before the limb attains its normal size. The crab uses extra resources to regrow lost limbs, which reduces the overall growth of the crab.

A small papilla is the beginning of a new leg.

A bud replaces the lost chelae.

Two or three moults take place before limbs attain their original size. The claw on the left is not fully grown.

A severe loss of either claws or more than four legs reduces the access to food and therefore the general growth. If the claws are ripped off, the break will not be at the fraction plan and the crab will loose a lot of blood and probably die.

Moulting

Along the Norwegian coast the main moulting season is from September to November. Moulting seems to start earlier in southern Norway and progresses northwards however, annual variations may occur.

Moulting is regulated by hormones. The process begins by the crab developing a new shell beneath the older existing one. The new shell is provided with minerals and pigments from the old shell which is slowly broken down by enzymes. Finally the shell cracks along a line which divides the upper and lower halves. The crab inside slowly backs out through the gap absorbs water and swells. The increase in carapace width is approximately 20 to 30 percent.

In the autumn "empty" crabs are often observed on the bottom. The line where the carapace has cracked is clearly seen.

After moulting the new exoskeleton commences to harden and within a few hours the final shell size is attained. After 6-7 days the shell is hard enough for the crab to start feeding. The crab shell is, however, still soft and the meat yield poor. Such crabs are called soft crab and later on pale crabs until their carapace are completely hardened. This may take about two to three months depending on temperature and food availability.

Newly moulted crabs start to rebuild muscles concurrent with shell hardening. However both soft and pale crabs still have poor meat yield and are full of water.

The upper part of the carapace is lifted to show the "empty" area where the gills and stomach have been. .

Left: Newly moulted (14.2cm carapace width). Right: The old skeleton of the same crab (11.8 cm).

Mating

Pairing occurs several days prior to moulting and is probably triggered by female pheromones attracting the male. Mating takes place immediately after the female has completed moulting

Copulation has been observed in the laboratory. During the moult the male remains astride of the female supporting his weight on the walking legs. On some occasions the male is observed assisting the female to moult by pushing off her old carapace with his claws. Immediately after moulting the male turns the female gently onto her back, unfolds her abdomen to expose the genital openings and deposits sperm into her oviducts.

"Paired-crabs".

For several days after copulation the male guards the soft-shelled and vulnerable female. The pair hides beneath rocks and in caves, and the male aggressively guards the entrance

The male is guarding the cave entrance where the soft-shelled female is hiding.

The sperm is stored in a "pouch" at the end of the oviducts called a spermathecae and can stay viable for several years. After copulation each oviduct is sealed by a plug created by glands in the mucous membrane.

The genital openings are "plugged".

The female is underneath. Notice her light brown claw tips, a sign of recent moulting.

Spawning, incubation and hatching

After moulting, the females new shell starts to harden, and muscles as well as the hepatopancreas, the main nutrient storage for the crab develop. Gonad development begins in the autumn, either in the same year as moulting takes place, or the following year. The latter is most common in crabs in the northern latitudes. The reproduction period ends with the female extruding (spawning) in late autumn and early winter. For the next 7-8 months, the eggs are attached to the female's abdomen.

A mature gonad just prior to spawning. The bright, red colour is due to the yolk.

In the spawning process the eggs are fertilized with sperm stored in the spermathecae. During the next 24 hours the fertilised eggs stick to the hairy appendages under the abdomen. The number of eggs varies from 0.5 million to 3 million, depending of the size of the female. The female crab can store live sperm in the spermathecae for one to two spawnings.

It takes about 24 hours for the fertilised eggs to stick to the appendages on the abdomen.

During the incubation period, i.e. the time from spawning to eggs hatching, the female hardly eats. Scuba divers have observed such berried female on sandy bottom well hidden under stones or rocks in depths of 20 – 25 meters. Berried crabs are also caught in deeper water as by-catch in gillnet and trawl fishery.

The main development of the larvae is initialized by the warming sea temperatures in May-June. As larvae with big black eyes develop, the red, bright coloured egg clutch transforms into a dark brownish clutch.

Hatching occurs mainly in July and August, earlier in the South of Norway and somewhat later further north.

The fertilized eggs develop while they are attached to the appendages under their mother's belly.

Berried crabs prefer a sandy bottom under stone and overhang

Annual migrations and catchability

Juvenile crabs are mainly found in habitats where they can find refuge and protection against predators.

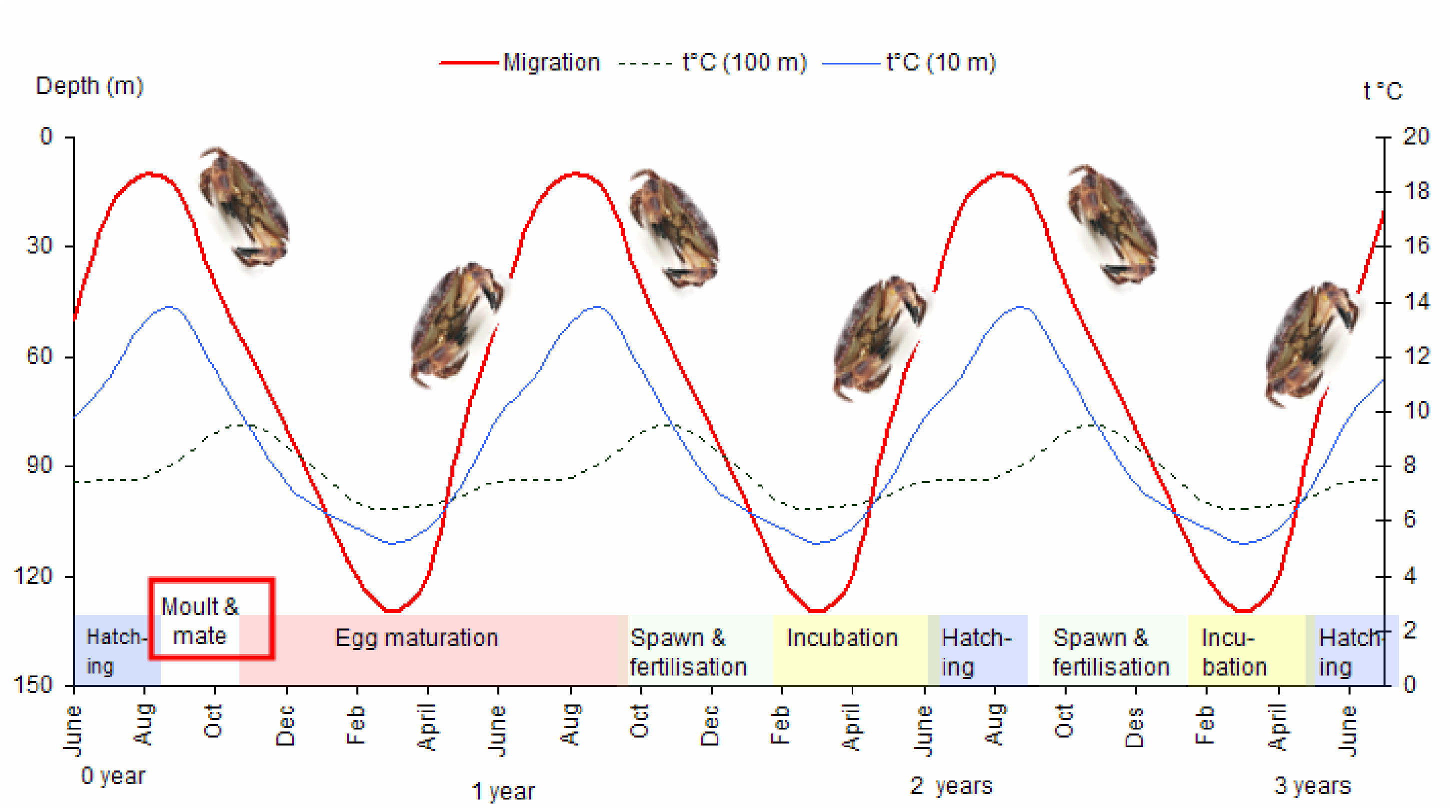
The adults undertake annual migrations. Most of them stay in deeper water during the winter season and migrate to shallower water in the summer season.

A diurnal or day and night migration is also observed. When darkness falls crabs tend to move into shallow water to feed on blue mussels and barnacles.

Annual migrations are also observed and appear to be more related to changing temperatures. During summer, temperatures are higher in shallow water in comparison to deeper water while the opposite is true during the winter. Crab activity and feeding decreases with decreasing temperatures. At temperatures below 4-5°C most crab activity has probably ceased.

Differences in migration patterns are observed between female and male crabs. Large females tend to migrate long distances while males are more stationary and staying within the same habitats. The females are thought to undertake long migrations in connection with their spawning and breeding cycles.

Crabs exhibiting nomadic migrations are probably searching for food.



The figure shows a 3-year spawning cycle for a female crab.

Feeding

Crabs are nocturnal animals. They act both as predators and scavengers. Like other cold-blooded animals, they can go without food for many days or weeks. In tagging experiments they have been observed to remain inactive for several days before starting a nomadic migration, probably in search of food.

When crabs feed they use their claws, mouthparts and "teeth-stomach" in order to gather, catch and cut up their food. A variety of prey items have been found in crabs such as bivalves, gastropods, barnacles, echinoderms and bristles worms. The attraction to bait in crab pots show that fish are also on the menu.

Blue mussels are the favourite food of crabs. The mussels shell is cracked by the chelae and the mussel is eaten bit by bit.

This soft crab is feeding voraciously on a sea urchin. Egg, shell and spines are all eaten.

Crabs are more or less omnivores. They are opportunistic and eat what is available. They have also been observed to eat red algae, stinging jellyfish and sea-squirts. Such prey items are easily digested and are not easy to identify in stomach analyses.

Crab hiding between sea-squirts which has also been observed to be on the crab's menu.

In the summer and autumn crabs migrate to shallow waters to forage on barnacles and small blue mussels on steep cliffs. This happens during the flood tide at dusk and night. Most of these migrating crabs are juvenile or soft-shelled and pale adult crabs.

Crab feeding on barnacles.

Crab orientation

Crabs orientate themselves according to the smells within their environment. Visual orientation seems to be of less importance. Crabs orientate themselves when searching for food, and when socially interacting with the opposite sex during the moulting and mating process.

A crab's ability to taste and smell is associated with dense rows of hairs that work like chemical receptors. These dense rows of hairs are located on the antennae (smell), legs, chelae and the mouthparts (taste).

Chemical attractants stimulate crabs to seek the source. This sets off a distinctive behavioural pattern from the time a crab locates bait until the bait is eaten. At first the antennae starts to move up and down (smell) And after a while the crab starts to move out of its place of residence (exploring). Eventually, the crab starts moving towards the bait. The speed of this reaction depends on the ambient water temperature and the crab's hunger.

The first sign of crabs detecting a smell is seen by the up-and-down moving of their antennae.

Crabs digging pits as they search for food such as mussels and bristle-worms.

The walking legs have dense rows of hairs which are chemical receptors (taste). The claws have chemical receptors which can be seen as small grooves in the outer part of the shell.

Diseases

At present, few diseases and parasites are known to interfere with the edible crab. However, break down of the shell is common in all crustaceans appearing as pits, melanisation and necrotic lesions of the claws and carapace.

Shell disease

The crustacean shell is hard and rigid, and built up of calcified chitin. A thinner outer lipoidal layer protects against different microbes which are found in the crab's environment.

Lesions and degradation of the shell are caused by chitin-digesting microbes which break down the chitinous layer. These microbes may be introduced by mechanical abrasions of the outer protective layer. These microbes, primarily of the genus *Vibrio, Pseudomonas* and *Aeromonas*, are natural habitants of the sea and not pathogenic to humans.

Melanisation, caused by enzymes in the crab blood, is typically found at the site of infections and is seen as a black discoloration. Large lesions can cause death during moulting due to adhesion between the exoskeleton and the underlying layers. Small lesions disappear with the old shell when moulting.

In unexploited stocks parts of crab population may have major attacks of shell disease due to a greater average and longer periods between moults. Thus exploiting such stocks may reduce the amount of crabs with shell disease.

" Pink crab disease "

During the autumn 2000 crabs from the Channel Islands had an altered pink or "cooked" colouration of the shell. Infected crabs generally had drooping limbs and died when handled. A *Hematodinium*-like dinoflagellate was found in the crab blood and associated with the disease. Because of the "pink" discoloration of the crab the disease is called "Pink crab disease". The flagellate has been previously found in *Nephros* and is widespread among the snow crab in Canada.

At present little is known about the seasonality, transmission and market impact of this disease on the edible crab.

Edible crab and toxic blue mussels

Blue mussels feed by filtrating micro-algae from the water. A toxin called DSP-toxin is produced of the micro-algae *Dinophysis* sp. Thus when this micro-algae is blooming the blue mussels become toxic. When crabs forage on toxic mussels the toxin accumulates in the hepatopancreas. Toxic crabs were observed in Norway in 2002 when an unusually long lasting and large *Dinophysis* sp. Bloom appeared in South-Norway. This led the Norwegian Food Authority to include crab in their monitoring program of toxic algae along the coast.

A major attack of "black-spot" disease.

Part 2. Grading specification in the Norwegian crab fishery

Primary quality
- **Females with high meat yield and roe (eggs)**
- **Both claws undamaged**
- **At least six walking legs**
- **No black spots or other shell discolourations**

Secondary quality
- **Females, that do not meet primary quality specifications**
- **Both claws must be undamaged**

Males
- **Both claws undamaged**

"Cripples"
- **Female or male crabs lacking one or two claws**

Discards
- **Dead crabs**
- **Crabs smaller than minimum legal size**
- **Egg-bearing crabs (berried crab)**
- **Soft-shelled crab**
- **Empty crab**
- **Crabs with a high prevalence of black spot disease or other shell discolourations**

All crabs are graded on board the boats by the fishermen. Crabs, which are not discarded, are graded in different categories depending on specifications given by the buyer. The categories and price per kilo is set according to agreements between the fishery sales organisations and the buyer prior to the crab season.

Females are graded into two categories (primary quality and secondary quality) while males are usually graded into one quality. However, crabs of both gender missing one or two claws may be sorted into one low-priced category according to predetermined agreements.

Meat yield varies throughout the year due to crab biology, but meat yield may also vary considerably in the different fishing grounds. The highest meat yield is found in autumn during the crab fishing season. However, at this time of the year, the moulting season starts and soft-shelled crabs enter the fishery. Hence, crabs of poor quality are mixed with crabs of high quality.

An effective grading system is therefore required to separate soft from hard shelled crabs where after soft-shelled crabs should be discarded. These may develop into crabs of high quality the following year.

Grading into different categories. When emptying the traps, fishermen have to carefully place the crabs into the boxes. To do this, the traps have to be close to the boxes.

Primary quality

- **Females with high meat yield and roe (eggs)**
- **Both claws undamaged**
- **At least six walking legs**
- **No black spots or other shell discolourations**

Females of primary quality have a hard shell with some fouling by epibiotic organisms. The colouration on the dorsal side of the shell is dark brown. The ventral part of the shell is creamy with darker pigmentation on the legs.

Secondary quality

Secondary quality crabs must have:
-**Both claws undamaged**
-**A hard carapace.**
Medium to high meat yield

Downgrading from best quality to secondary quality may occur based on the presence of external damage to the body such as:

- missing more than 2 walking legs
- carapace disfigurement, e.g. several black spots or lesions, or a high prevalence of fouling organisms on the shell.

This crab has a high prevalence of fouling organisms on the shell.

This primary quality crab is downgraded to secondary quality because of poor external body conditions such as black spots on the claws.

Left: All these crabs have a hard shell. Some of them are of primary quality while others will be downgraded to secondary quality due to lesions, black spots and a high prevalence of fouling organisms on the shell.

Discard

Crabs below the minimum legal size, soft-shelled crabs and berried females should be returned to sea immediately after capture. Crabs with severe lesions, black spots or other shell discoulorations ought to be destroyed. They should not be discarded back onto the fishing grounds as they may still be a source of further infection.

Minimum legal size

Crab size is measured across the widest part of the carapace. From Rogaland and further north along the Norwegian coast the minimum legal size is 13 cm. In Rogaland and southward to the Swedish boarder the minimum legal size is 11 cm carapace width.

Egg-carrying females (berried)

Egg-carrying females are caught during two periods: in July/August and from October until the end of the crab season (Nov/Dec). Very few berried crabs are caught in traps, on average only 0.1 – 1% of the total catch.

Females start to spawn in October. Berried females caught thereafter have recently spawned and the egg-clutch is bright red. Spawning may occur in the traps.

Berried females caught in July/August, 7-8 months after spawning, carry larvae that are close to hatching. These greyish/brown eggs are larger in size and have eyes that can be seen. Hatching takes place over several days.

Soft-shelled crabs

Crabs grow by moulting. The interval between each moult increases with age, from moulting annually at the size of sexual maturation (11–13 cm) to moulting every 2 – 3 years for older crabs.

It takes about 2 to 3 months for the shell to fully calcify and completely harden. Most of the crab's energy during this period is used to build up the new shell. At the same time pigmentation also increases. Secondly, muscle tissue in crabs also increases and energy reserves are stored in the hepatopancreas (glycogen) and in the blood.

Carapace width, measured at the widest part of the shell.

Newly spawned (Oct- Jan).

Egg-clutch just before hatching.

Crab with egg-clutch which has nearly finished hatching.

Meat yield mainly depends on how much time has passed since the last moult. The shell hardness is therefore an important indicator for meat yield.

Discard – soft- and pale-shelled crabs

Soft-shelled crabs have recently moulted and the shell is soft. Pale-shelled crabs have started to build up the new shell, but have not finished the calcification. Soft and pale shelled crabs are of poor quality, as meat yield is low and water content high.

It is difficult to determine the intermediate phase between soft and pale shelled crabs. The hardness of the shell can be assessed by pressing the carapace on the ventral side just at the base of the claws. If the shell buckles, the calcification is not complete and meat yield is probably poor.

The hardness of the shell can also be assessed by the colour and the prevalence of fouling organisms.

Soft-shelled crab claws are very light on the lower side. As the calcification process proceeds, the pigmentation increases.

The shell of soft-shelled crabs buckles when pressed at this point – reject.

The age of the shell can be determined by the colour of the hair and the outer appendages. Above: Hard shell, the hairs and outer appendage colouration is dark brown. Below: Newly moulted, the hairs and the outer appendages are light brown.

The walking legs change colour as the calcification process progresses. This is best seen on the inner, long joint of the legs. From left to right: hard, pale, and soft-shelled crab legs.

*Left: **Soft-shelled crab**. Carapace is clean with no fouling organisms. Colour on dorsal carapace is brownish-red. The ventral side of the carapace is greyish-white and tips of the claws brownish. Meat yield is poor.*

*Right: **Pale-shelled crab**. Carapace is clean with no fouling organisms. Colour on dorsal carapace is brownish-red. Ventral side of the carapace is greyish with more pigmentation than the newly moulted soft-shelled crab. Assessing the intermediate phase between soft-shelled and pale-shelled crabs may be difficult, especially immediately after the crab is taken out of the trap. Pale-shelled crabs still have a poor meat yield and are of poor quality.*

Discard – ”empty” crabs

Hard-shelled crabs may also be of poor quality. These “empty crabs” can be divided into different categories:

- **Females with recently hatched eggs**
- **Just prior to moulting**
- **High prevalence of shell disease**
- **Old shells (several years since moult)**

Recently hatched

Females, which recently have hatched larvae (July/Aug) are hungry and easily enter a baited trap. Remnants of eggs and eggshells may be found on the pleopods. The shell of the female crab is usually dirty after 7-8 months of hiding under stones and being partly buried in sand.

Due to the high prevalence of fouling organisms this shell is estimated to be at least 2 years old. The crab may be empty. Check other signs before discarding.

Weight

Crabs with a hard shell and high meat yield are heavier than poor quality crab with a hard shell. This grading may be difficult when the crab is directly taken out of the trap.

Enlargend genital openings

When the crab is taken directly out of water, the genital openings will at first bulge. After exposure to air for sometime, the openings enlargen in poor quality crabs.

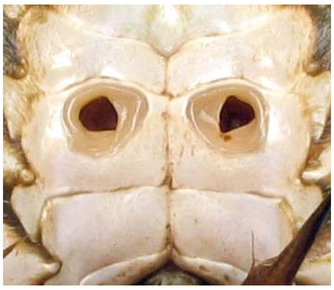
Shell disease

Crabs with a high incidence of bacterial and fungi growth on the shell are weakened and have a low meat yield.

These crabs have a high prevalence of shell disease. Meat yield is poor.

Pleopods full of dirt and clay. Remnants of eggs and eggshell are present.

A soft-shelled crab recently taken from sea. Genital openings bulge, and after a while in air they will enlargen.



A hard shelled crab following several hours of air exposure. The genital openings have widen out, indicating an empty crab.

Primary quality crab – criteria for meat quality

The external appearance of crabs gives some indication of the meat yield. However, to be absolutely sure the crab has to be opened. Primary quality crabs must meet certain criteria in terms of external appearance and additionally have a high meat yield, i.e. high meat yield of muscles (white meat), hepatopancreas (brown meat), and roe (for the females).

Primary quality female crabs must have a nice outer carapace, claws and walking legs intact as well as a high meat yield of white meat, brown meat and roe.

Primary quality females – meat yield and nutritional values

Meat yield

Meat yield for boiled and hand picked female crabs of first quality. Yield calculated for females, which on average were 0.5 kg live weight and caught in October.

	Yield (gram)	Yield (%)
Claws	32	6.3
Walking legs	14	2.6
Body	28	5.5
Sum white meat	74	14.5
Sum brown meat	48	9.5
Sum roe	28	5.5
Total meat yield	*151*	*29.4*

Nutritional values

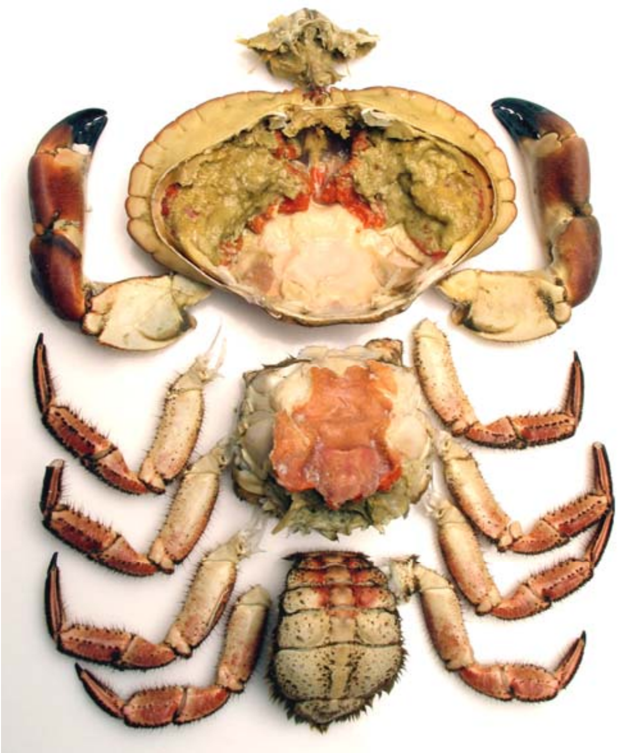
Nutritional value (g per 100 g) for white meat, brown meat and roe for females of high quality caught in October:

	White meat	Brown meat	Roe
Lipid	0.2	14.8	7.4
Protein	23.1	13.5	28.0
Ash	2.2	4.4	2.1
Carbohydrates	1.0	2.9	6.9
Dry matter	26.5	35.6	44.5

Hepatopancreas (brown meat)

The colour of the hepatopancreas varies according to season and habitat. The colour is affected by the diet. Feeding trials have shown that the brown meat becomes lighter after 10 days feeding with the fish pollack.

The colour of hepatopancreas is on average darker in crabs from Norway compared to other countries such as Ireland, and the taste is stronger.



Crab divided in fractions

The colour of the brown meat varies considerably. Dark brown/greenish meat (picture below) is not accepted in several markets.

Part 3: Handling live crabs

General rules

- **The crab should be handled with care**
- **Avoid direct exposure to sunshine, wind and rain**
- **Keep the crab humid by covering the upper box with sacking, and / or wetting them with the hosepipe**
- **Deliver the crab within the same day as catching. If this is not possible let the crabs get access to seawater**
- **Crab should be alive on delivery**

SE-40 boxes can store 38 - 40 kg of crabs. In small boats stacked boxes are very handy because of the saving of space when the boxes are stored.

Different boxes are used to store the crab on board. Wooden boxes were used originally, but are now replaced by plastic boxes. The crab is usually delivered in the same boxes as they are stored on board. On delivery the fishermen get empty boxes in return according to the arrangement between the fishermen and the buyer prior to the crab season. Boxes can also be hired from specialised firms and the user pays for the hire and the washing of the boxes

The use of stacked boxes has increased. This system allows the boxes to be nested when returned or stored. Such boxes are produced in different sizes and shaping. In the Norwegian crab fishery the SE-40 box are frequently used. The height of SE-40 is 25 cm. When they are nested the height of 30 boxes is 230 cm.

Some boxes can only be stabled like NorBoks 90 (picture) which can store 50 kg of crabs.

To increase survival it is important that the crab is handled with care - not thrown into the boxes

Holding crabs on board

Dehydration of the crab is reduced if exposure to direct sunlight and draught is avoided. Small changes in the general routine onboard can improve this.

Covering the upper box

Covering the upper box with wet sacking ensures that crabs are maintained in a high humidity environment. Evaporation of the damp sacking also gives a cooling effect. The same effect is gained by covering with wet wood wool, kelp or newspapers.

Wetting the crab

Several fishermen have installed simple, but efficient systems for wetting the crab with seawater. This may simply consist of an extra hose connected to the hosepipe on board. Some of the boats have additionally water taps for every stack which allow them to regulate the water flow and change the flow to different stacks. The crabs are not nicked and must therefore be tightly stacked in the boxes to avoid damages caused by the claws. Some boats have possibilities for storing the crabs in the hold.

The crab fishery in Norway is mainly limited to the crab season from August to November. The fishermen usually combine the crab fishery with gillnet or long-line fishery in the winter season. This combination demands an adaptation of the boats for both fisheries.

Left: The upper boxes are covered with wet sacking.

Right: SE–40 boxes stacked in the hold. A wetting system is installed in the ceiling

Below: Installed water taps make it possible to regulate the water flow and change the flow to different stacks.

SE-40 boxes stacked on the port side of the boat. The tarpaulin protects against draught

A simple wetting system coupled to the hosepipe

Holding in seawater

If the crab is stored for more than one day without cooling it should be held in seawater.

Holding the crabs in seawater in specially designed crates is labour demanding. On delivery the crabs have to be transferred to other boxes while dead and weak crabs are sorted out.

When holding the crab for more than one day, a general practice in Norway has been to stack the crabs in specially designed crates immersed in sea. This practice entails extra work for the fishermen. Often the crab has to be transferred from one box into the crates, a practice which causes extra stress and damage to the crabs. The crabs must be tightly stacked in the crates to avoid damage and mortality caused by the crab's claws

When storing crab at sea, it is important that the water has a stable salinity higher than 30 ‰. The water current should also be strong enough to provide an adequate supply of oxygen to the crab.

If environmental conditions are unstable in the surface layer the crates should be lowered in the water, ensuring that they are no lower than 1 meter from the bottom. Lowering the crates is important when the surface temperature increases, which may lead to depleted oxygen levels, and when heavy rainfall dilutes the salinity in the surface.

Alternatives

Crabs may be hosed in boxes placed on the deck or on the quay instead of keeping them in crates in the sea.

Left: A water flow of more than 100 l per min fills the SE-boxes. This flow gives sufficient oxygen in a stack with 6-7 boxes when the sea temperature is at lower than 12°C.

Right: The holes in a SE-40 box are suitable to give a satisfactory water flow through.

Physiology and environmental conditions

Salinity

The edible crab is considered to be limited to seawater and the tolerance of rapid changes in salinity is small. The crab should be held in stable seawater with salinity higher than 30 ‰. In fresh water there will be a lack of salt compared to the concentration in the cells. In order to get the same concentration the smaller water molecules will penetrate into the crab's cells and the crab will slowly die.

Temperature and oxygen demand

Temperature conditions are very important for the welfare of the edible crab. The crab shows an increase in oxygen uptake with increasing temperature. At 16°C the oxygen demand is doubled compared to 8°C. When the temperature decreases below 5°C the crab do not feed and the oxygen demand is very low. When crabs are kept in cold water, the flow can be reduced.

Effects of temperature changes

Crabs are 'cold-blooded'. This means that the core temperature is the same as the ambient temperature. When the water temperature changes the core temperature changes rapidly as the crab pumps water through the gill chambers. When the crab is emersed and the air temperature changes, it takes several hours for the core temperature to reach the ambient air temperature.

The crab is vulnerable to large and rapid temperature changes in seawater. As a rule, water temperature increases of greater that 5 to 6°C should be avoided.

Excretion of wastes

Ammonia is the main waste product of the metabolism. It is primarily released by the gills. The ammonia excretion rate increases when the temperature increases and decreases when the temperature is lowered or if the animal is passive or starved.

Like other animals the crab has to get rid of carbon dioxide released by the metabolism. This excretion also occurs through the gills.

If the crab gets too little oxygen, e.g. when transported dry or if it is kept in water with insufficient flow, a switch to anaerobic pathways of energetic production occur. This cause changes to the blood biochemical composition and acid-base balance. In particular, an increased utilization of carbohydrate and lactate production may be observed followed by the onset of blood acidosis.

When crabs are kept in air foam is occasionally observed around the mouthparts. High ammonia content is found in the foam indicating that the crab may get rid of accumulated ammonia through it.

Holding crab in air

Shellfish can, within certain limits, be kept in air without further damage or mortality. When transported dry, the function of the gill is inhibited and metabolic wastes accumulate mostly in the blood. When re-immersed the animals get rid of the wastes.

Temperature

How long crabs survive in air depends on:

- Air temperature and humidity
- Pre-treatment of the crab
- Quality of the crab

Temperature is the most important. At the receiving plants, crabs are usually held in cooling rooms at 4-5°C. When treated in this way the metabolism decreases thus increasing the holding time.

Accumulation of ammonia

When the crab is exposed to air, ammonia excretion is impeded as the gills cannot function effectively. This leads to increased blood ammonia levels. There comes a time when the ammonia has poisoned the animal sufficiently to cause its death - a slow process which may take a further 1 or 2 days - even if the animal is returned to water.

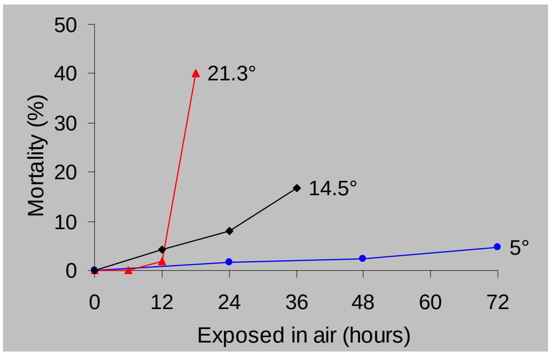
Revitalisation

When the crab is re-immersed it will ”dump” a lot of the accumulated ammonia during the first 5-10 minutes. After a long period exposed to air it may take 24 hours before the acid-base balance is re-established.

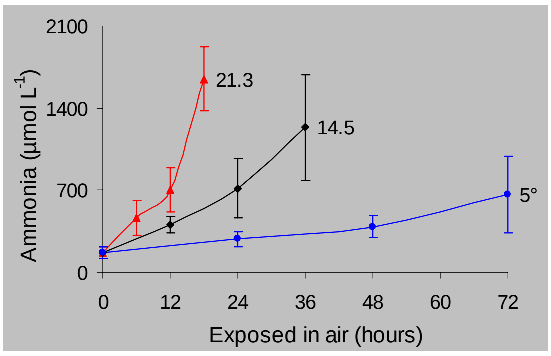
When re-immersed the crab will throw up stomach content and get rid of excrements. The holding water should therefore be changed some hours after re-immersion.

Loss of weight during emersion

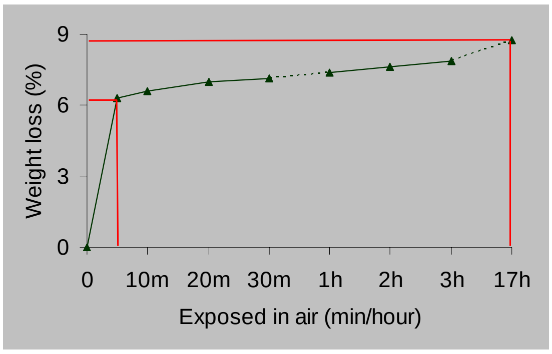
The crab dehydrates when it is kept in air. During the first minutes of emersion the crab spits out the water in the gill chambers. Thereafter the dehydration continues gradually, however, quicker when the air temperature is high and humidity low.



Mortality for crabs during periods exposed to air at different temperatures. Woll 2005.



Accumulated ammonia in crab-blood during periods exposed to air at different temperatures. Woll 2005



Dehydration of crabs kept cool and humid. During the first 5 minutes the crabs loose 6% weight, thereafter gradually, and after 17 hours additionally 3% loss. Woll&Tuene 2001.

“Viviere” boats and “viviere” trucks

About 80% of the landings in UK and Ireland are distributed at the live market in Europe. The distribution chain is therefore different compared to the Norwegian crab fishery where most of the crab is processed.

Most of the landings in UK and Ireland come from a-whole-year offshore-fishery conducted on the continental shelf outside 12 n. miles on depths from 25 to 200 m. This fishery is conducted with especially designed “super-crabbers”. During the catch process the crabs are held in “viviere tanks” filled with seawater flowing through. A “super-crabber” can keep the crab for 5 days in such tanks. To avoid damage the claws are inactivated by nicking the tendon immediately after catching.

When unloading the “super-crabbers”, the crab is put directly into tanks in “viviere trucks” at a ratio of 1:1 crab and water. Transport time to the European market is approximately 36 hours. The seawater in the “viviere tanks” is aerated, but is neither chilled nor using biofilter. When the crab reaches the European market, it is re-immersed in seawater at ambient temperature. To avoid temperature shock it is recommended that the animals are prevented from experience more than a 5 to 6°C temperature change between the seawater temperature and the temperature in the “vivier tanks”.

Ammonia levels in the “viviere tanks” may reach toxic values during transport, particularly in the warm season. This leads to mortality during transport or during the days following re-tanking at the end point

Super-crabber”.

Nicking the tendon which operates the crab’s claws. The tendon should be tensed during this process.

The tanks in a ”viviere truck

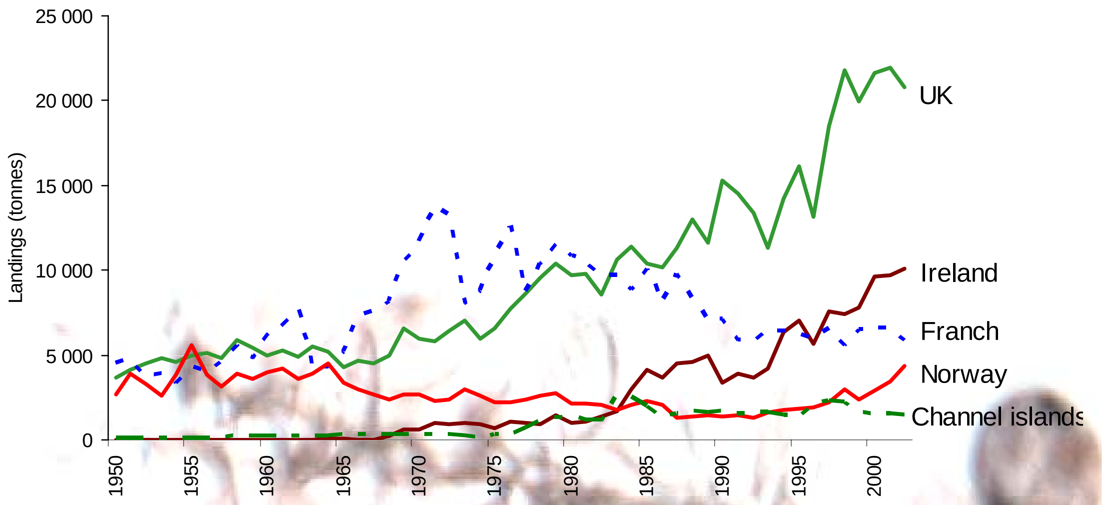
The fishery for Edible crab

The edible crab (*Cancer pagurus*) has been exploited in Norway since the start of the 20th century. Crab landings increased during the past decade from 1732 t in 1994 to 5236 t in 2004.The main fishery is in Mid-Norway and Helgeland (63°–67°N), which together land 75% of the Norwegian catch.

Norwegian landings of Edible crab separated for the different sales organisations.

Sales oranisation	N latitude	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Norges Råfisklag	63°- 69°[1)]	1 157	1 161	1 362	2 134	1 963	2 187	2 714	3 311	3 780	4 030
S&Romsdal	62°-63°	51	62	45	52	35	29	87	160	95	28
Vest-Norge	60°-62°	258	281	323	408	352	306	300	435	621	669
Rogaland	58.30°-60°	338	279	389	401	556	382	334	395	434	506
Skagerakfisk	58.30°	-	-	-	1	-	-	-	-	2	3
Sum (tonnes)		1804	1783	2119	2996	2906	2904	3434	4301	4932	5236

UK and Ireland have at present the largest edible crab fishery. The landings in UK has been about 20,000 tonnes in recent years and in Ireland about 10,000 tonnes. The Norwegian landings are about 10 % of the total landings in Europe.



Landings of Edible crab in Europe from 1950 to 2002. Data from FAO: Fishstat Plus.

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Norwegian Raw Fish Organisation (www.rafisklaget.no)

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