

Commercial scale sea urchin roe enhancement in Norway: Enhancement, transport and market assessment

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Report

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<p><i>Summary/recommendation:</i></p> <p>This report describes a commercial scale sea urchin roe enhancement trial run in collaboration between Nofima and Lyngsskjellan AS. It was conducted in Lyngen, northern Norway, utilizing urchins harvested in Tromsø, the SeaNest holding system and the Nofima sea urchin roe enhancement feed. The urchins showed a significant increase in gonad index (GI) over the 10 week enhancement period (from an initial GI of 3.9 % to a final enhanced GI of 20.3 %) which is a typical increase for this species, fed this diet over 10 weeks. The survival of the urchins was lower at the conclusion of the trial compared to previous trials undertaken by Nofima and it appears there may have been a stress event occurring for the urchins between the 5 week and 10 week samples. After 10 weeks of enhancement, the urchins were harvested and distributed to restaurants in Norway and a sea urchin processor in Hokkaido, Japan for quality assessment. The results from the Norwegian restaurants showed the urchins were considered good quality for 3 of the 4 restaurants. The Japanese processor assessed the urchins and found they were in good condition post transport, they had good colour, but were rather soft and did not have a strong, or sweet flavour. They sold the sample on the Tsukiji Seafood Market and the results showed that the product sold for the mid-range price for imported urchins of this species. The transport techniques used and the market value of the sea urchin product are discussed in the final sections of the report.</p>	
<p><i>Summary/recommendation in Norwegian:</i></p> <p>Denne rapporten beskriver en test som er gjennomført for å forbedre kråkebollerogn i kommersiell skala. Dette er et samarbeid mellom Nofima og Lyngsskjellan AS. Testen ble gjennomført i Lyngen, Nord-Norge, og det ble benyttet kråkeboller høstet i Tromsø, SeaNest oppdrettssystem og Nofimas diett for kråkeboller. Kråkebollene viste en signifikant økning i gonadeindeks (GI) over 10 ukers forbedringsperiode (fra en opprinnelig GI på 3,9 % til en endelig GI på 20,3 %), noe som er en typisk økning for denne arten når den gis denne dietten over 10 uker. Overlevelse av kråkebollene var relativt lav ved avslutningen av testen sammenlignet med tidligere studier gjennomført av Nofima, og det ser ut til at det kan ha vært en stressende hendelse for kråkebollene mellom uke 5 og 10. Etter 10 uker med ekstra fôring, ble kråkebollene høstet og distribuert til restauranter i Norge og til en kråkebolle-prosessor i Hokkaido i Japan, for kvalitetsvurdering. Resultatene fra de norske restaurantene viste at kråkebollene ble vurdert å være av god kvalitet for 3 av de 4 restaurantene. Den japanske prosessoren vurderte kråkebollene og fant ut at de var i god tilstand etter transport; de hadde god farge, men var ganske myk og hadde ikke en sterk eller søt smak. Smaksprøver ble solgt på Tsukiji Seafood Market, og resultatene viste at produktet selges for en mellompris for importerte kråkeboller av denne arten. Transportmetoder som brukes og markedsverdien av kråkebolleproduktet diskuteres i slutten av rapporten.</p>	

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1 Executive summary

This report begins with a brief introduction to the URCHIN project, funded by the Northern Peripheries and Arctic Programme (NPA) 2014-2020.

It then describes a commercial scale sea urchin roe enhancement trial run in collaboration between Nofima and Lyngsskjellan AS. The roe enhancement trial was conducted in Lyngen, northern Norway, utilising wild harvested sea urchins from Tromsø. The commercially available SeaNest holding system and the Nofima sea urchin roe enhancement feed were used in the trial. The urchins showed a significant increase in gonad index (GI) over the 10 week enhancement period (from an initial GI of 3.9% to a final enhanced GI of 20.3 %). This increase in roe content is typical for this species (*Strongylocentrotus droebachiensis*), fed the Nofima roe enhancement diet for 10 weeks based on previous research conducted by Nofima. The overall survival of the sea urchins was relatively low after 10 weeks compared to previous trials. Observations from the trial indicate that there may have been a stress event between week 5 and week 10 sample points.

The sea urchins were harvested after 10 weeks of the enhancement trial and distributed to four restaurants in Norway and one sea urchin processor in Hokkaido, Japan for quality assessment. Three of the four Norwegian restaurants considered the sea urchins to be of good quality. One very high-end restaurant did not consider the sea urchins good enough quality. The price that the restaurants were willing to pay for the product was relatively high but the scale of the Norwegian restaurant market is very small. The Japanese processor assessed the sea urchins and found they were in good condition post transport and the roe had good colour (specific to this market requirement). However, the roe texture was rather soft and did not have a strong or sweet sea urchin flavour. The Japanese processor sold the processed roe sample on the Tsukiji Seafood Market and the results showed that the product sold for the mid-range price for imported *S. droebachiensis*. Given the stress event experienced during the final weeks of the roe enhancement trial and the long transport to Japan (39hr) the market value attained is reasonable given the circumstances but is considerably less than the price offered by domestic Norwegian restaurants. The Japanese market is the world's largest market for sea urchins and sea urchin roe. Therefore, the market potential is huge but the relatively low value of the product and high transport costs must be considered when investigating the viability of roe enhancement in Norway for the Japanese market. The European market, primarily the French market which is the second largest market for sea urchins when compared to the Japanese market, is likely to be a more economically viable option due to higher value, lower transport costs and the relatively large scale of the market (compared to the Norwegian market).

Alongside the roe enhancement trial a simulated transport trial was carried out which indicated that it was possible to send urchin for up to 44hr packed in 'isopro' boxes with gel ice and they will arrive alive and in relatively good condition. However, the trial also tested long-term survival when urchins were transported and then kept alive for two weeks. The results showed that urchins transported 44hr had a significantly higher mortality than those transported for 34hr (or less). This is an important consideration when transporting urchins for roe enhancement trials, and/or transporting urchins to any live holding facility.

2 Introduction

2.1 URCHIN project (Utilisation of the Arctic Sea Urchin Resource)

The URCHIN project aims to utilise the sea urchin resource present in the northern arctic regions. The challenges of fishing, sustainable and responsible harvesting of stocks, legislation and supply chains for sea urchin products from isolated and environmentally harsh and challenging areas in the Northern and Arctic region will be addressed. The challenges will be overcome through innovation and national and transnational technology transfer.

Currently there are small scale (<150 tonne p.a.) intermittent fisheries for sea urchins in the NPA. This is despite there being enormous sea urchin resources present in the area. There are a number of challenges that have prevented the expansion of sea urchin fisheries in the NPA. These include environmental challenges to fishing, inadequate and inappropriate legislation and fisheries management and lack of technology and knowledge regarding sea ranching and roe enhancement of poor quality urchins. Research to overcome these challenges has been disparate and there has been no previous transfer of knowledge between the NPA partner countries.

This project aims to gather the existing expertise from Norway, Iceland, Ireland and Greenland, together with knowledge from Canada to optimise the fishing of high value sea urchins in Northern and Arctic areas. Furthermore, roe enhancement technology from Norway for roe fattening to increase the value of low value sea urchins once they have been collected in the northern arctic regions will be developed in Greenland and Iceland. The project would also investigate sea ranching to repopulate areas that have been extensively overfished in the past in Ireland. Issues regarding the provision of adequate legislation and fisheries management will be identified and legislative organisations will be provided with the appropriate knowledge to provide sensible and sustainable management of sea urchin fisheries. The project will also estimate market capacity for sea urchin roe as well as establishing logistic routes from the NPA to markets.

2.2 Scope of this report

The specific aim of this report (Part fulfillment of Activity 5.2.1 of the URCHIN project, see Appendix 2) is to transfer knowledge on existing techniques for roe enhancement between NPA countries, research institutes and SME's. The Nofima roe enhancement feed used in the current trial has been extensively researched but its commercial application has been limited. The current roe enhancement trial in Norway will provide feedback from both Norwegian and Japanese markets regarding the quality and the price structure of the roe product from enhanced sea urchins. Enhanced sea urchin roe product has not previously been sold in the Japanese market. This report will also describe the trial and transport protocols used by the commercial mussel farm in Norway and will disseminate the knowledge necessary to run similar trials in other NPA countries.

3 Commercial scale roe enhancement trial in Norway

3.1 What is roe enhancement?

Roe enhancement is defined as the capture of wild, mature sea urchins of suboptimal quality for either selling whole and live or for processing and selling of the roe product. These can be collected from areas of low feed availability, poor environmental conditions or from urchin ‘barrens’ where urchins are present at very high densities. Once the urchins have been collected they can be held in either land or sea-based holding systems and fed natural or manufactured feeds to enhance the roe. Enhancement means increasing the quantity of the roe (i.e. increasing the percentage GI) as well as improving the quality and consistency of the product. This mainly refers to the colour, texture and taste of the resulting roe. For more information and previous research conducted on roe enhancement on the green sea urchin (*Strongylocentrotus droebachiensis*) see James and Siikavuopio (2013a), James and Siikavuopio (2013b), and Siikavuopio and James (2011).

3.2 Trial methodology

The trial was conducted at an SME site which is a family owned mussel farm (Lyngsskjellan AS) in Lyngen in northern Norway (approximately 3 hours drive north of Tromsø) (Figure 1). The trial was part funded by the NPA URCHIN project, part internally funded by Nofima and the feed used in the trial was funded by Kaston AS.

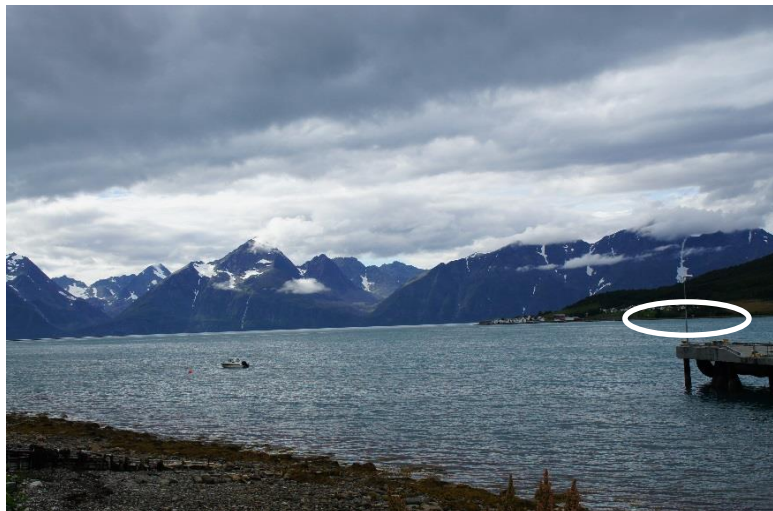


Figure 1 The area where Lyngsskjellan AS is located in Rotsund, Lyngen. The farm is situated just offshore (circled) in the right of the picture on the island of Uløya.

3.2.1 Urchin collection

The urchins used in the trial were harvested in Kvalsund (40 minutes drive from Tromsø) and were collected by a SCUBA diver (Figure 2 and 3). Approximately 1200 urchins were collected.



Figure 2 The area (inside the small harbor) in Kvalsund, Tromsø where the urchins were collected.



Figure 3 The site (underwater) where the urchins were collected and the diver collecting urchins.

3.2.2 Urchin transport

The urchins were collected into catch bags in the sea until they were ready to be packed and transported. They were then placed in the back of an enclosed pick-up vehicle (the compartment was airtight so there was no effect from wind etc). They were covered with wet (soaked in seawater) hessian sacks and a tarpaulin to ensure a dark, moist cool environment. They were then driven from Kvalsund to Lyngsskjellan AS in Rotsund, Lyngen (approximately 3hrs).

On arrival, the urchins were transferred to a small boat, covered with the sacks and tarpaulin, and delivered to the mussel barge at the farm site (10 minutes boat trip). Once on site they were distributed randomly into 10 SeaNest crates that had been prepared and were put together in two stacks of three crates and one stack of four at a density of approximately 130 urchins/crate. An accurate count was made after a two week period to allow for harvesting and transport mortality.

At the conclusions of the experiment, the urchins were removed from the crates and the same transport technique was used to deliver the trial sea urchins back to Tromsø where they were placed into SeaNest crates at the Nofima sea-based site at Kårvika for four days to purge and recover from the return transport. After the purging period, the urchins were packed in 'isopro' containers with gel ice and an absorber sheet. Samples (approximately 2kg were sent to three restaurants and 10kg to one restaurant with live holding facilities) were transported to restaurants in Norway and 35kg were transported to a sea urchin processor in Hokkaido, Japan for processing, packaging and selling into the Tsukuji market in Tokyo, Japan.

3.2.3 Holding systems

During the trial the urchins were held in SeaNest crates. The SeaNest system has been especially designed for holding sea urchins and extensively tested in Norway, Japan and several other countries and are recognised to be an excellent commercially available holding system for sea-based sea urchin roe enhancement (Figure 4).

Approximately 130-140 sea urchins were placed in each of the 10 crates which equates to a stocking density of approximately 40 % coverage of the available internal surface area (excluding the lid).



Figure 4 The SeaNest holding system used to hold sea urchins in the Lyngsskjellan AS farm.

3.2.4 Feeding regime

The sea urchins were fed the formulated Nofima sea urchin roe enhancement diet at a rate of 0.1% of their total wet weight (approximately 300-400g/crate/feed) once per week for nine weeks. The final feed in week ten was not given due to the imminent collection and transport of the urchins. In order to feed the urchins the stacks were removed from the water and dismantled into individual crates, the sea urchins were fed and the stack system reassembled and placed back in the water. Feeding was conducted in the evening and when the weather was calm to avoid extremes of temperature fluctuation and negative effects of wind and sun.

3.2.5 Trial monitoring

Survival

To keep the transfer times to a minimum the animals were distributed into the crates as rapidly as possible with an approximate count into each crate (140 urchins/crate). The sea urchins were then kept in the SeaNest crates for two weeks and photos were taken of each crate during a feed event. These images were then analysed and the precise number of urchins in each crate was recorded. This was used as the 'initial' number of urchins in each crate (post transport mortality). At the conclusion of the trial when the sea urchins were removed from the crates a 'final' number was recorded. The mortality was calculated by calculating the percentage of surviving urchins between the initial and final counts.

Sea urchin sampling

Sample size: A sample of 40 sea urchins was collected at the same time as the initial wild urchins were harvested. These were stored in a catch bag in the sea until the following day when the test diameter and gonad index was measured (40 urchins) and a histology sample was collected (20 urchins). After five weeks a sample of 40 sea urchins from the holding crates (four from each crate) were collected and measured. At the conclusion of the trial another 40 sea urchins from the holding crates were

collected and measured (4 from each crate) and another 40 urchin sample were collected from the wild at the original collection site in Kvalsund. The test diameter and gonad index was measured from both the enhanced and wild final samples (40 sea urchins from each) and a histology sample were collected (20 sea urchins from each).

Urchin size: The size of the sea urchins was measured using vernier calipers to measure the widest test diameter (TD) of each sea urchin. The wet weight of each sea urchin was measured using a two decimal place scale.

Urchin GI: To assess the GI of an individual sea urchin the whole animal was weighed (total wet weight of sea urchin), the gonads were removed and cleaned and then also weighed (wet weight of gonad) (See Figure 5). The GI was then calculated using the following formulae:

$$\text{GI (\%)} = \text{Wet weight of gonad (g)} / \text{Total wet weight of sea urchin (g)} \times 100$$

Histology sample: The method for collecting the roe samples for histology was as follows (Figure 5): a thin (2-3mm) slice was removed from the middle section of a single roe (each sea urchin has five roe) with a sharp clean scalpel. The slice was placed into a histology labelled cassette which was then be placed in 5-10 % buffered formalin. The samples were then sent to the Veterinærinstituttet in Harstad for staining and fixing. The resulting histology slides were examined under a microscope and staged.

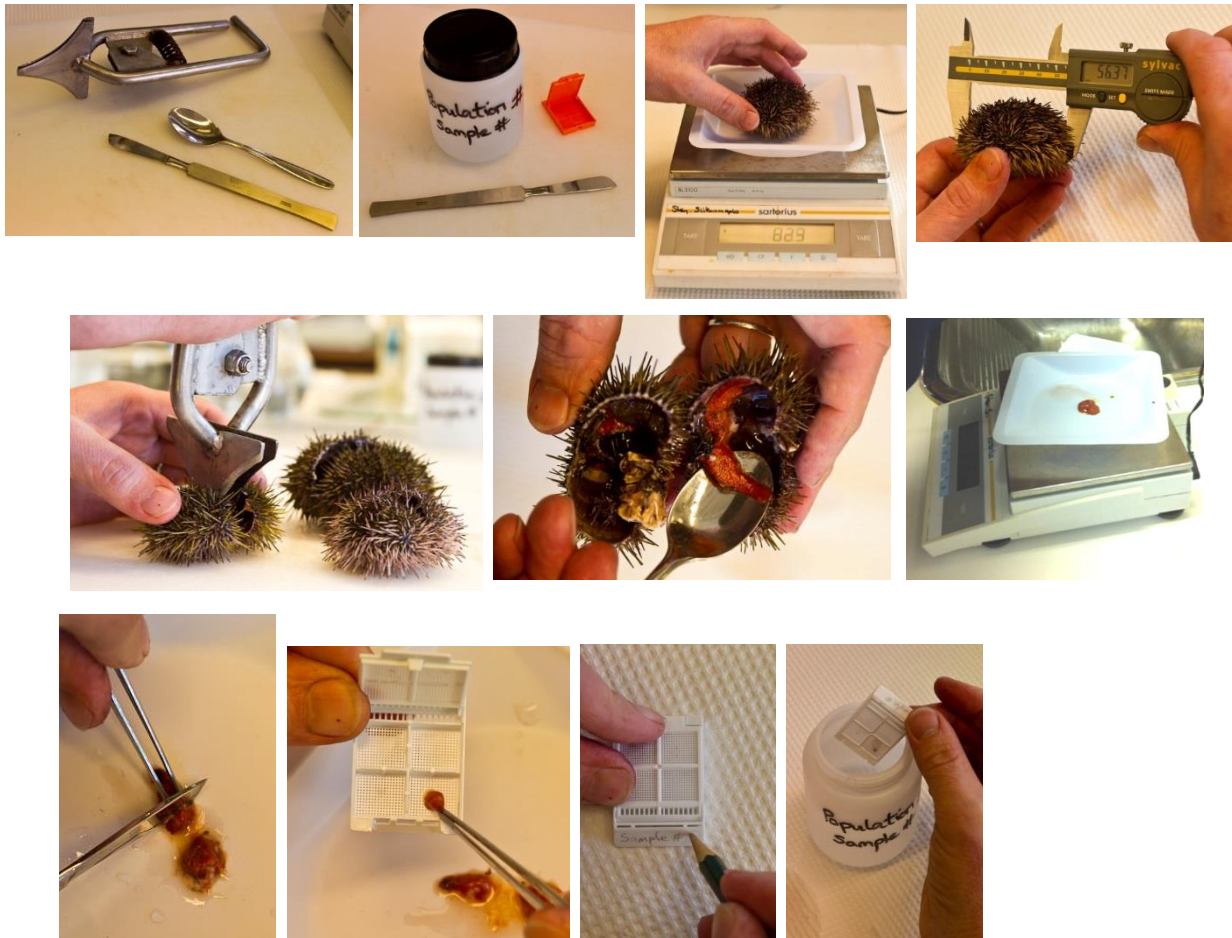


Figure 5 The process for sampling the roe of a sea urchin and preparing a histology sample: (A and B) the equipment required includes a sea urchin opener, a spoon, a scalpel; a histology cassette and a plastic container with 5-10% formalin solution; (C) weighing the whole live sea urchin; (D) measuring the test diameter of the urchin; (E) opening the urchin; (F) removing all 5 gonads; (G) weighing the 5 gonads; (H) removing a small section from the middle of the gonad; (I) labelling the plastic container and histology cassette; and (K) placing the sample in formalin solution.

3.3 Results

3.3.1 Survival

The initial counts in the 10 SeaNest crates (taken two-week post transport) and the final counts, together with the percentage survival are shown in Table 1.

Table 1 The Initial and final number of urchins and the percentage survival from each crate.

	Initial number in crate	Final number in crate	% survival
Crate 1	127	94	74,0
Crate 2	134	56	41,8
Crate 3	132	74	56,1
Crate 4	117	75	64,1
Crate 5	133	124	93,2
Crate 6	117	94	80,3
Crate 7	125	35	28,0
Crate 8	119	104	87,4
Crate 9	125	53	42,4
Crate 10	121	73	60,3
Average survival			62,8

3.3.2 Sea urchin size and Gonad Index

The average size of the sea urchins (wet weight and test diameter), gonads (wet weight) and gonad index (%) of the urchins at each sampling is given in Table 2. Photos of sample sea urchins at each sampling period are shown in Fig 6, 7 and 8 (initial, 5 week and 10 week respectively).

Table 2 The average size of the urchins (wet weight and test diameter), gonads (wet weight) and gonad index (%) of the urchins at the initial, 5 week and 10 weeks samples. Results for wild samples are shaded dark grey and enhanced urchins are shaded light grey.

	Average wet weight (g)	Average test diameter (mm)	Average Gonad weight (g)	Average GI (%)
Initial (wild)	41,5	46,2	1,7	3,9
5 week (roe enhanced)	66,1	54,8	9,3	13,9
10 week (roe enhanced)	54,4	51,5	11,1	20,3
10 week (wild)	46,8	48,9	3,3	7,0



Figure 6 Sea urchins from the initial wild collection.



Figure 7 Sea urchins from the five week census of roe enhancement trial.



Figure 8 Sea urchins from the ten week census of the roe enhancement trial.

3.3.3 Histology

The histology results (Table 3) show that there was little difference in the reproductive stage of the wild sea urchins collected at the beginning or at the end of the 10-week trial. Given that this is a relatively short period in the 12-month reproductive cycle of the sea urchins this is not unexpected. The sea urchins from the enhanced sample were at a similar stage to the final wild sample but had more storage cells present than the initial and 10 week wild samples (this was not measured quantitatively).

Table 3 The percentage of sea urchins in each of the four reproductive stages from the initial and final wild samples and the final enhanced sample (n = 20 urchins from each sample).

		Stage I	Stage II	Stage III	Stage IV
Initial (wild)	Male	0%	70%	30%	0%
	Female	0%	90%	10%	0%
10 week (wild)	Male	0%	64%	36%	0%
	Female	0%	78%	22%	0%
10 week (roe enhanced)	Male	0%	92%	8%	0%
	Female	0%	88%	12%	0%

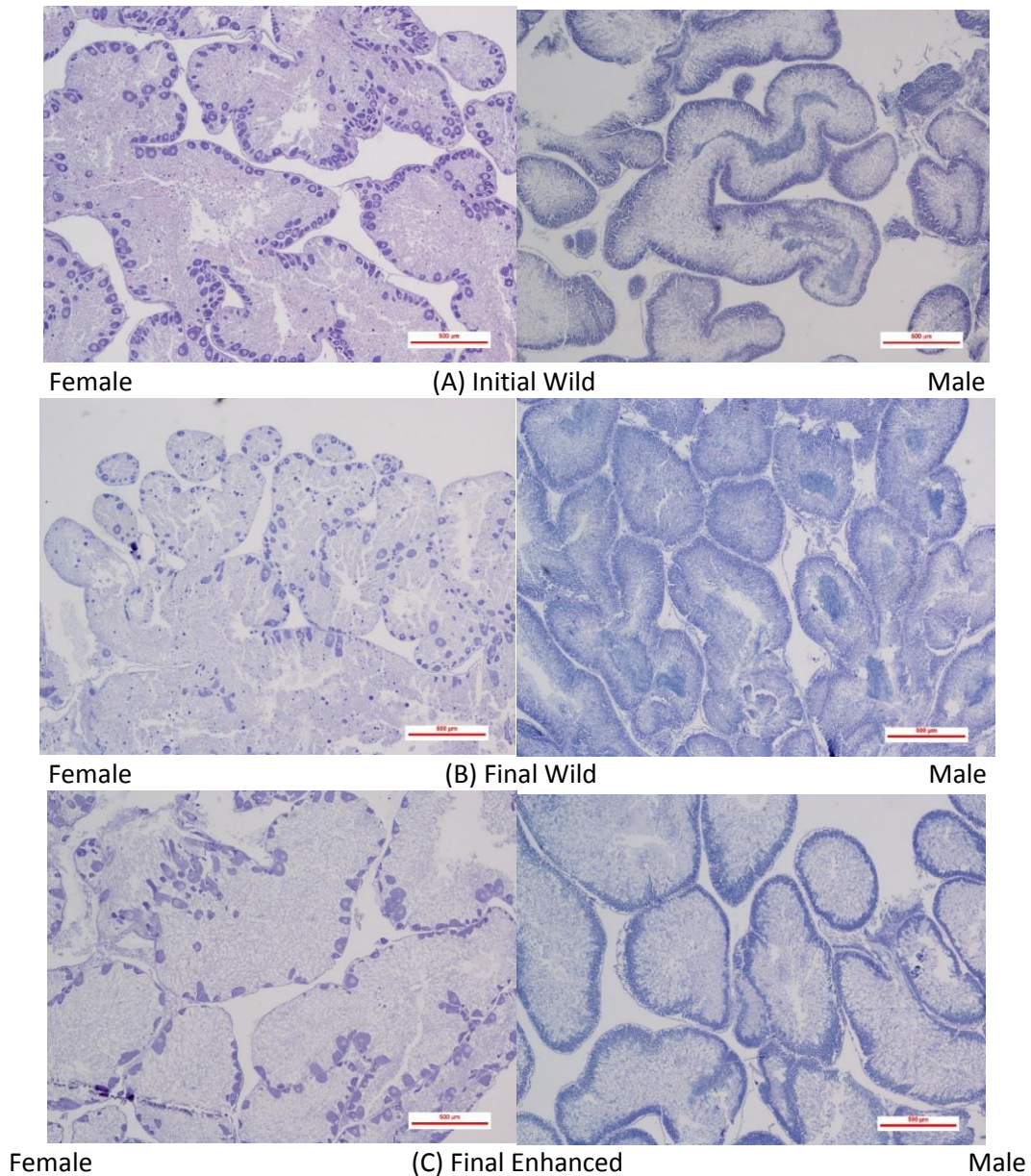


Figure 9 Examples of the histology slides (female on left and male on the right) collected from (A), the initial wild sample, (B) the final wild sample and (C) the final enhanced sample.

3.4 Discussion of results

3.4.1 Survival

The survival rates in the current trial are relatively low compared to previous roe enhancement trials that have been conducted by Nofima (Siikavuopio and James 2011). In two previous studies, adult sea urchins held in roe enhancement trials experienced 100 and 99 % survival respectively over periods of 12-weeks (James and Siikavuopio, 2013a and 2013b). Normal maximum mortality rates of 1-5 % would be expected in a commercial trial such as this one. Very high mortality (above 50%) was experienced in four of the ten SeaNest crates which could indicate that some of the experimental units experienced conditions that were suboptimal (low temperatures, or high winds) during feeding events. This mortality was experienced despite these negative environmental conditions being specifically avoided

by the farm operator during feeding. The cause of the mortality may also relate to other factors experienced by the urchins during the trial. These can be predation, which is unlikely in the SeaNest crates, as they do not allow access to predators. Cannibalism can also be an issue with sea urchins held at high densities but the dead urchins in this trial did not have the characteristic bald spots normally associated with adult sea urchins cannibalising other adult sea urchins. It is very difficult to say the exact cause of the urchin mortality. Anecdotal evidence from the farmer suggests that the mortality occurred gradually over the ten-week trial and gradually increased in the final five-week period.

3.4.2 Increase in gonad index

The GI of sea urchins in the wild can be variable and in some cases, can be less than 1 %, or, as high as 20 % whereas, for enhanced sea urchins GI values can be up to 35 % (Siikavuopio and James, 2011). Factors that affect GI are feed availability, environmental conditions such as temperature and the reproductive cycle of the sea urchin. In roe enhancement trials sea urchins are fed a high-nutrient formulated feed. Similar trials have repeatedly been shown that sea urchins rapidly increase their GI regardless of the reproductive stage (although this can have a significant impact on transport success and roe quality) and water temperature. The GI of the sea urchins in the current trial increased from 3.9 to 13.9 % in the first five-weeks (total increase of 10 % GI) followed by a further increase from 13.9 to 20.2 % in the last five-weeks of the ten-week trial (an addition of 6.3 % GI). This displays that the increase in GI slowed significantly in the final five-weeks. In previous trials, the increase in GI remained constant over a 10-12 week enhancement trial, this indicates that underlying cause of the sea urchin mortality may have also limited the increase in GI in the final stages of the trial.

3.4.3 Histology and reproductive stage

For a full review of the reproductive cycle, the reproductive stages and their impact on sea urchin roe enhancement see James and Siikavuopio (2012). The histology results from this trial do not show any large variation in the reproductive stage of the sea urchins over the ten-week enhancement period. This is not surprising given the reproductive cycle occurs over 12 months and the changes in reproductive stages are relatively slow and incremental. What is important to note is the reproductive stage of the sea urchins in the current trial, the time of year the trial was run, and how this will impact on other roe enhancement trials conducted at different times of the year. The reproductive stage of the sea urchin roe can have a significant impact on roe quality. The reproductive stage that the sea urchins were at in the current trial (Stage II/III) was very suitable with large quantities of nutrient storage cells being present rather than reproductive cells. The presence of large quantities of reproductive cells during the later reproductive stage (Stage IV) can cause spawning during transport and loss of quality in the product. Sea urchins in spawning condition are considered very low quality in Japan and other markets. The results of this study will contribute to the knowledge regarding the impact of the reproductive cycle on future large-scale sea urchin roe enhancement endeavours.

4 Sea urchin packing and transportation trials

A simulated transport trial for live sea urchins was undertaken to investigate possible transport times to deliver live, whole, good quality sea urchins to a processor, markets or to restaurants in both Norway and Japan. The results of the simulation trial were used to pack and transport sea urchins from the trial within Norway and to a processor in Japan.

4.1 Trial 1: Simulation transport trial

The following transportation trial investigated whether it was feasible to transport sea urchins alive and in good condition for periods up to 44 hours.

4.1.1 Methodology

Sea urchins were collected from Kårvika and held in the sea in catch bags until they were packed into 'isopro' (polystyrene) boxes. The urchins were randomly allocated to one of six boxes (treatments) that were packed with the following urchin quantities and ice gel packs:

Urchin quantity and quantity of ice gel packs

- 1.6kg urchins/box, 4 gel packs (2kg)/box (Box 1,2 & 3)
- 2.4kg urchins/box, 7 gel packs (3.5kg)/box (Box 4, 5 & 6)

The six boxes were then exposed to various transport periods:

- 24 hours transport (Box 1 & 4)
- 34 hours transport (Box 2 & 5)
- 44 hours transport (Box 3 & 6)

During the transport periods, the isopro boxes were stored in a cool room (approximately 10-13°C). After 24, 34 and 44hrs respectively they were opened and the condition of the sea urchins and any mortalities were recorded. Sea urchins from each box (treatment) were then placed separately (72 urchins / treatment) in plastic baskets in stacks in the sea at Kårvika for 14 days. During this period the sea urchins were fed the Nofima diet and at 7 days and 14 days checked for condition and survival.

4.1.2 Results

The results of the trial proved there was virtually no immediate mortality resulting from the transport periods used in the trial (only one urchin died during transport, Table 4). All the urchins appeared to be in good condition when removed from the transport boxes with only one recorded mortality at this stage of the trial. After seven days storage in the sea-water holding systems there was still very limited mortality ranging from 1.4 % in the 1.6kg packs held for 24 and 34hrs to 6.9% in the 2.4kg pack after 44hrs transport. After 14 days storage mortality levels increased and was considerably higher in the 44hr transport treatment, regardless of the amount of sea urchins packed in the box (16.7 % and 20.8 % for urchins in the 1.6kg and 2.4kg respectively) (Table 5). There was very little difference in mortality (2.8-5.6 %) in the 24 or 34hr treatments regardless of the amount of sea urchins in the packs (Table 4).

Table 4 Sea urchin mortality and condition, and gel pack condition immediately after transport period.

Box Number	Length of transportation	Appearance at end of transportation	Condition of freezer packs		Mortality at end of transportation (individual urchins)	
			4 freezer packs	7 freezer packs	1.6 kg urchins	2.4 kg urchins
1 & 4	24 hours	Excellent	½ frozen	2/3 frozen	1	0
2 & 5	34 hours	Very good	½ frozen	2/3 frozen	0	0
3 & 6	44 hours	Very good	Defrosted	Slightly frozen	0	0

Table 5 Sea urchin mortality from the six treatments after 7 and 14 days storage in sea-based holding systems.

Treatments				Post transport mortality			
Box number	Number (weight) ice packs	Weight of urchins	Transport period	7 days		14 days	
				Actual number	Percentage of total	Actual number	Percentage of total
1	4 (2.0kg)	1.6 kg	24 hour	1	1.4%	4	5.6%
2	4 (2.0kg)	1.6 kg	34 hour	1	1.4%	2	2.8%
3	4 (2.0kg)	1.6 kg	44 hour	5	6.9%	12	16.7%
4	7 (3.5kg)	2.4 kg	24 hour	2	2.8%	4	5.6%
5	7 (3.5kg)	2.4 kg	34 hour	4	5.6%	4	5.6%
6	7 (3.5kg)	2.4 kg	44 hour	5	6.9%	15	20.8%

4.2 Trial 2: Commercial packaging and transportation from Norway to Japan

Following the simulated packing trials 25kg of urchins were packed using the same techniques as used in the simulated trials (each container had 3.5kg of ice gel and approximately 5kg urchins) and sent to a processor in Hokkaido, northern Japan.

4.2.1 Method and results

The sea urchin consignment was delivered to Tromsø airport following packing of the animals directly from the sea-based holding system at Kårvika, Tromsø (3 hours packing and transport to airport in total). The consignment was delivered to Tromsø airport at 4:30am and the flight to Oslo departed at 5:30am. The total flight time from Tromsø to Narita, Tokyo was 26 hours. Following arrival at Narita the urchins went through the following monitoring process (the result are shown in Table 6):

Time record of sea urchins consignment after arrival at Narita, Tokyo (Date 14/Sept/2016)

- 12:20 SAS flight arrived at Narita airport
- 14:30 Customs Clearance
- 15:10 Cargo released to our forwarder
- 16:45 Received from forwarder Flight check-in
- 17:25 Departure Local flight to Chitose, Hokkaido

- 19:20 Arrival Chitose airport
- 19:45 Departed Chitose by car
- 22:40 Arrived at the Processor (Thyms and Co Ltd, Hokkaido) where the packs were opened and sea urchins placed in a chiller (lids were put back on due to the low temperature in the chiller) overnight until processing the following morning.

(Total 10 hours 20min in Japan prior to opening of packs).

Total time-frame for travel from Tromsø to processor:

Packing and transport to airport	3 hours
Flight time	26 hours
Time to processor	10 hours
TOTAL transport time:	39 hours

Report from Japanese processor on condition of sea urchin an arrival in Japan:

- On arrival at the Processor, the inside temperature of each carton was measured without opening the lids. The average inside temperature was 14.3°C.
- On arrival, a visual inspection showed the urchins were in good condition with almost 70-80 % of urchins still alive and their spines moved slowly when touched. Almost all spines remain standing upright (See Figure 9 A).
- Due to the late arrival time at the processor the sea urchins were kept in cartons in a chilled room (-1.6°C) overnight. Due to the low temperature in the chilling-room the lids were kept on.
- On 15th September at 9:00am, the inside temperature in the cartons was checked again (this had fallen to 11.8°C). Each individual carton was weighed (net weight). The results are displayed in Table 6. Approximately 8 % drip (loss of sea urchin wet weight in the form of water loss into the packaging container) was measured and almost all sea urchins were dead by this time.
- The sea urchins from number 4 carton were selected for test processing on the same day. Total gonad weight was 900g exactly from 100 individual sea urchins = 4,708g (Origin weight) or 4,360g (arrival weight). Yield of gonad was 19.1 % (from Origin weight)
- The sea urchins were then packed in 100g small boxes which are a standard for packing sea urchin roe in Japan (Figure 9c and D).

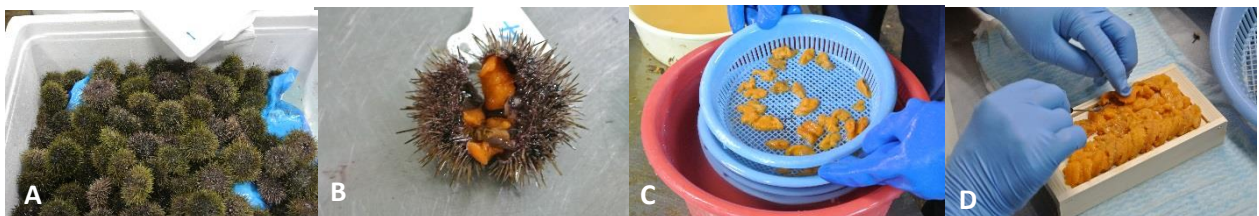


Figure 10 Sea urchins on arrival at the processing plant in Hokkaido (A), being opened (B), cleaned and sorted (C), and packed in traditional trays for sale (D).

Table 6 The temperatures, weight and weight loss of each carton during transport to Japan (recorded by Japanese processors).

Carton No.	Inside Temp at arrival (°C)	Weight (g) at Origin	Weight (g) at Processor	Difference (g) (Drip)	Lost Drip (%)	Temp (°C) Next morning
1	14.2	5 167	4 740	427	8.26	12.0
2	14.9	5 336	4 920	416	7.80	10.2
3	14.5	5 088	4 660	428	8.41	12.3
4	14.0	4 708	4 360	348	7.39	13.3
5	13.9	5 204	4 780	424	8.15	11.1
Total	71.5	25 503	23 460	2 043		58.9
Ave.	14.3	5 101	4 692	409	8.01	11.8

4.3 Trial 3: Commercial packaging and transportation to Norway, quality and market report

In addition to the 35kg of sea urchins packed and shipped to Japan, four containers of sea urchin were delivered to restaurants in Norway. Two of the containers were hand delivered to a sushi restaurant (2kg) and a fine dining restaurant (2kg) in Tromsø. One container was sent to a fine dining restaurant in Oslo (2kg) and 20kg were sent to a live seafood restaurant in Bergen. The maximum travel time was to the Bergen restaurant and the urchins arrived in excellent condition after approximately 10hrs.

4.4 Discussion (packing, transport trials)

It is important to define the market requirements for 'live' sea urchins. If sea urchins are to be delivered alive and ready for processing or immediate consumption then the packing utilised in the current trial is sufficient for at least up to 44hrs transport. If sea urchins are required for storage in a holding system and remain alive for an extended period, then the techniques used in this trial appear to be effective up to 34hrs transport. Two-week post transport mortality increased when transport periods were increased from 34 to 44 hours in this current trial further research is required to identify what the critical periods are for live transport.

5 Market/value assessment from roe enhancement trial

5.1 Japanese market

The Japanese processor in Hokkaido provided a quality assessment on arrival in their processing plant. After processing and packing in traditional packaging (Figure 11) the processed product was sold by auction at the Tsukiji Seafood Market, Tokyo, Japan (the world's largest sea urchin market).

5.1.1 Japanese processor quality assessment

Comments from the processor regarding roe quality at the processing plant:

- The quality of the urchins at delivery to the processor was good. As long as freshness is good, dead sea urchins are not problematic. The quality of sea urchins received from Canadian or U.S. east coast origin is much lower as spines flatten and occasionally the sea urchins have an unwanted smell.
- Urchin sizes were generally on the small side. The larger size sea urchins in the samples were the normal preferred size of Japanese sea urchins.
- The roe itself is considerably softer than other products, but roe colour was very good (in line with market requirements).
- After immersing in 'alum water' (standard processing procedure for increasing gonad firmness) for 30min. After this procedure the roe was still softer and waterier than the normal Japanese product.
- The taste is considered weak and does not have enough flavour or sweetness for top grade value.

5.1.2 Market evaluation from sale of sea urchin roe in Tsujiki Fish Market

- The sea urchin roe from the Norwegian roe enhancement trial sold at the Tsukiji Market for 1000 ¥ / 100g roe.
- The top price paid for this species imported into Japan is 2000 ¥.
- This equates to 10.5 NOK (1.2€) / individual urchin exported whole & processed in Japan (Note: this does not take into account transport or processing costs).



Figure 11 Sea urchin roe packed into 100g containers and ready for sale on the Tsukiji Market in Tokyo, Japan.

5.1.3 Estimated size of Japanese market

The Japanese sea urchin market is a market where supply never exceeds demand. However, the prices are very dependent on the sea urchin species and the roe quality.

5.2 Norwegian market

5.2.1 Method and results

Four restaurants were supplied with sea urchin samples and asked to complete a questionnaire survey describing the quality of the roe and whether they would be likely to use this type of product (see attached in Appendix 1). Three of the four restaurants thought the roe quality was good and it would be a useful ingredient in their restaurant. The live seafood restaurant served the sea urchins to patrons and they were well received and the ability to receive regular quantities of live, good quality sea urchins was seen as being very advantageous by this restaurant.

5.2.2 Value of product

The price received for sea urchins in Norway is the same regardless of the origin of the sea urchin (wild or enhanced) but a premium price is received for products with guaranteed amounts of high quality roe. The enhanced product has a much better consistency and roe content than normal wild catch.

- Norwegian restaurants market:
Range between 300NOK – 800NOK kg/whole live urchins (equates approximately to 33€ - 87€ kg/whole live urchins on current exchange rates)
- The most likely price will be 300-400NOK/kg and this equates to 15-20NOK/single live whole urchin (equates approximately to 1.6€ - 2.2€/single live whole urchin)

5.2.3 Estimated size of Norwegian market

Relatively small (estimated maximum 5-10t p.a.)

5.3 Alternative markets

5.3.1 European market

The following information is based on sales data for *S. droebachiensis* collected from Iceland and sold through the Boulogne Sur Mer seafood market in France:

- Wild urchin prices: 4-7€ kg/whole live urchins
- Price for frozen roe: 30-60€ kg/frozen roe
- Price for enhanced roe: Unknown!

Research into the value of enhanced urchins from the NPA area are continuing, including roe enhancement trials in Iceland and Ireland (as part of the URCHIN project). The current European market price for *S. droebachiensis* appears to be lower than for *Paracentrotus lividus*.

5.3.2 Estimated size of European market

This is unknown but currently there are 120-150t exported from Iceland through the Boulogne Sur Mer seafood market in France. This does not meet the demand in this wholesale market and there are a number of other seafood wholesale markets also selling sea urchin products throughout Europe that are undersupplied.

6 Summary

Despite the relatively high mortality in the final stage of the trial, the results are promising for commercial scale roe enhancement at the small farm scale in Norway. The farm that ran the trial is now running a second trial to supply the restaurant with live holding facilities that tested the urchins from the first trial. If this is successful, it is possible that they can then carry on supplying enhanced sea urchins on a continuing small scale to Norwegian restaurants.

The market information in this trial came from Norway and Japan. This was combined with information from a sea urchin fishery and processor in Iceland where the same species of sea urchin is fished, processed and sold as live whole urchins and as processed roe in the European market. The results indicate that the European market is the most likely large-scale market for enhanced roe from Norway and the NPA as a whole. It is more economically viable to get product to this market, rather than the Japanese market. The European market accepts live whole animals and the prices are comparable to those from the Tsukuji market in Japan without the added processing and transport cost. The prices quoted from this trial would be unlikely to cover the costs of enhancement, freight and processing in Japan unless very large quantities are supplied, or, the urchins could be sold for a significantly higher price in the Tsukuji market, or in other similar seafood markets than those from the current trial. The local Norwegian market is likely to be a suitable market for low volume high value sea urchins. This market will offer lucrative prices but will remain a small sustainable niche market for operators within the sector.

7 References

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Appendix 1: Questionnaire used in the Norwegian restaurant survey

Sea Urchin Questionnaire

1) How would you rate the overall quality of the sea urchins (size and condition)

1	2	3	4	5	6	7	8	9
(poor)								
(excellent)								

2) How would you rank the overall quality of the sea urchin roe

- Size

1	2	3	4	5	6	7	8	9
(poor)								
(excellent)								

- Colour (1 being poor and 10 being excellent)

1	2	3	4	5	6	7	8	9
(poor)								
(excellent)								

- Taste (1 being poor and 10 being excellent)

1	2	3	4	5	6	7	8	9
(poor)								
(excellent)								

3) Is this a product you would use in your restaurant?

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4) If the product could be supplied consistently, what volumes would you use, and how often would you need them delivered?

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5) What do you think a realistic price (per kg whole urchin) would be for product supplied consistently at this size and quality?

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6) Can you provide a quote regarding what you think of this product?

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Appendix 2

This report fill the partly fulfils the requirements of the following two outputs:

Activity 5.2	<i>Activity title:</i> Land based roe enhancement adding maximum value to harvested urchins	<i>Start month</i> 03.2016	<i>End month</i> 03.2017
<i>Description</i> Market sized <i>P. lividus</i> are still harvest in Ireland for sale a supply to the export market. This market is low volume and high value for the middle buyers and wholesalers, by forming co-ops and working with buyers in Ireland it will be possible to add extra value to each urchin sold and with the possibility of maintaining a steady supply during the winter season due to inclement weather. Harvesting will take place during favorable conditions when the GSI is low and the urchins will be fattened in land-based facilities prior to sale or export. GSI is linked to the market value of the urchins so standardisation of roe size and quality for each urchin sold will increase the market value.			<i>Deliverables</i> Report to SME's on the value added urchin product in conjunction with coops and buyers to increase the market value for urchins from the NPA region
5.2.1	<i>Deliverable:</i> SME report	<i>Target value:</i> Delivered to a minimum of 10 SME's in NPA.	<i>Delivery month</i> 03.2017

Activity 6.1	<i>Activity title:</i> Markets for sea urchins	<i>Start month:</i> 03. 2015	<i>End month:</i> 12.2016
<i>Description:</i> Current markets for sea urchin and roe will be evaluated with a focus on European markets, especially markets in regions close to the NP area.			<i>Deliverables:</i> A report on current and emerging markets for sea urchin (whole) and roe
6.1.1	<i>Deliverable:</i> Market report	<i>Target value</i> Delivered to a minimum of 10 SME's in NPA	<i>Delivery month</i> 12.2016

