NOTE: GENULÆG: MUSSELS RELAYING FROM THE FACTORY TO AREA 15

Written by: Camille Saurel, Mia Gommesen, DSC DTU Aqua – June 2014

ABSTRACT

Between 2011 and 2013, two experiments were conducted on the relaying of mussels and discard from the mussel factory industry to area 15 by the vessel Limfjorden.

The mussel factory industry discard material consists of a mixture of live undersized mussels, shells, stones and other bivalves. Some allocated plots are used in the Limfjorden to relay this material. Different sorting and treatments were tested in order to evaluate the amount of material harvestable from these relayed beds. In 2013 three different treatments of material to discard were relayed at different densities: fine sorting 10kg m^{-2}, fine sorting 20kg m^{-2}, 3kg fine sorting + 6kg dredge m^{-2}. Samples were taken twice after relaying, in 2013 and 2014. Seventh months after relaying, only 8% of the 20kg m^{-2} was blue mussel and it reached a maximum of 14% after a year relayed; empty shells represented most of the sample: 85%. The 10kg m^{-2} treatment started with an average of 24% of mussels 2 months after relay, but lost the entire mussel population in one of the location due to heavy starfish predation and had a maximum of 33% in an area without the presence of starfish. Finally the 3+6 kg m^{-2} had an average of 25% and 33% mussels 7 months and a year after relay respectively. The density of mussel biomass in the 20 kg treatment was the lowest, while it was the highest for the 3+6kg treatment. Visual footage of the different treatments shows the very high percentage of empty shell mixed to the samples, the high presence in some case of cockle population mixed with the mussels and finally in the 3+6kg treatment there was a high sediment coverage that might ultimately reduce the mussel growth.

INTRODUCTION

Between 2012 and 2014, two sets of experiments were conducted in Area 15 used for the relay of different treatments for composition and density of mussel discard by the mussel processing factory. During the processing of the dredged mussels by the industry in the factory, small mussels and other living organisms are discarded and relayed by the vessel Limfjorden in designated plots of area 15 Sallingsund (Figure 1).

The dredged mussels are loaded from the fishing boat to a container on land. The mussels are brought to the factory where there is a pre-sorting with removal of stones, wastes, undersized mussels and other non-relevant material (Sorting 1). Sand is washed away from the mussels. Then a second sorting occur (Sorting 2). The discarded material is collected in containers and loaded in the vessel Limfjorden (Figure 2). The discarded material is relayed on the selected sites in area 15 Sallingsund (Figure 1 and Figure 2).

The aim was to investigate whether the different composition and different density of discarded material were performing once relayed for improving the management of the relayed material from discard. Here we only present the results for the second experiment, carried out in 2014 with 3 types of treatments.

MATERIAL AND METHODS

EXPERIMENTAL DESIGN

Between 2012-2014, mussels relayed by the Limfjorden were sampled, and the list of the sampling events is summarized in **Table 1**.

a. Phase 1: 2012-2013. Bucket sampling from the factory were collected prior to the relaying. Samples were collected with a dredge from the relaying plots. Video recording were done in July 2012
   i. Sorting 1: coarse sorting relayed at a density of 10kg m^{-2}
   ii. Sorting 2: fine sorting relayed at a density of 10kg m^{-2}
   iii. Mix 1: relayed at a density of 3kg m^{-2}
   iv. Mix 2: relayed at a density of 10kg m^{-2}
b. Phase 2: 2013-2014. Sampling in the relaying plots was done via a diver using ring samples. Video recording was done in one position of each relaying plots.
   i. Sorting 2: fine sorting relayed at 10kg m^{-2}
   ii. Sorting 2: fine sorting relayed at 20kg m^{-2}
   iii. 3+6kg: 3kg of discarded material + 6 kg of dredged mussels from Lovns and skive area relayed at 10kg m^{-2}

Table 1: list of the sampling events for the two phase of the industry relaying experiments.

Plots \ Date	April-June 2012	July 2012	March 2013	17/04 2013	28/06 2013	11-12/12 2013	03.04.2014
Mix 1 (10kg)	Factory - relay	Dredge+video	Dredge				
Mix 2 (10kg)	Factory - relay	Dredge+video	Dredge				
Sorting 1 (3kg)	Factory - relay	Dredge+video	Dredge				
Sorting 2 (10kg)	Factory - relay	Dredge+video	Dredge				
3+6 kg				relaying		2 positions 10 ring samples video	3 positions 10 ring samples video
Sorting 2 (10kg)				relaying	3 positions 10 ring samples video		3 positions 10 ring samples video
Sorting 2 (20kg)				relaying		2 positions 10 ring samples video	3 positions 10 ring samples video

Figure 1 shows the relaying locations in area 15 for both experiments.

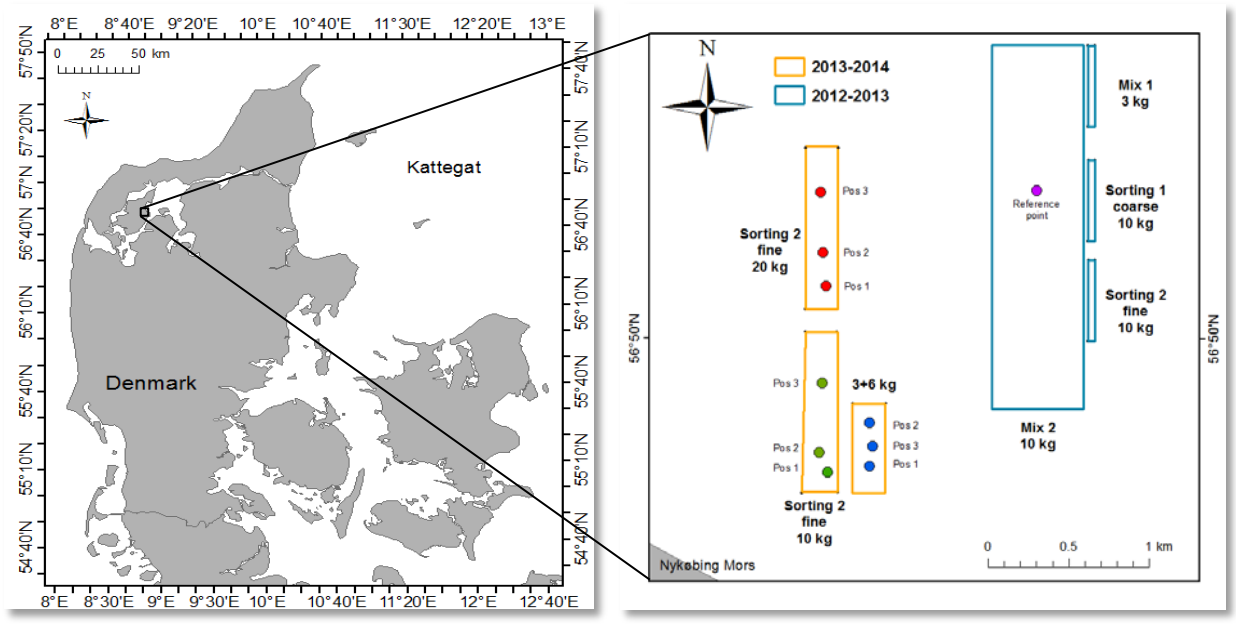


Figure 1. Maps of Denmark and relaying position in area 15 for the different treatments in phase 1: 2012-2013 and in phase 2: 2013-2014.

Figure 2. Photos of an example of transfer of discarded material from the factory to the Limfjorden vessel, and from the Limfjorden to the allocated relay plots in area 15 Sallingsund (April 2014).

FIELD MEASUREMENTS

Samples from the dredges or the ring samples were sorted onboard of the boat. Total weight of the sample, live mussel, shell, rocks and other living organism weight were recorded. New recruits when present were recorded. For each dredge in phase 1 (2012-2013), three subsamples were taken and the weight of mussel caught per second or per dredged area were calculated.

Once the samples were collected, they were transported immediately to the laboratory at the Danish Shellfish Centre in Nykøbing Mors where they were either sorted or stored into raceways until sorting. Once sorted, mussels were frozen until morphometric measurements took place. Two types of sampling measurements were conducted see details in Table 1.

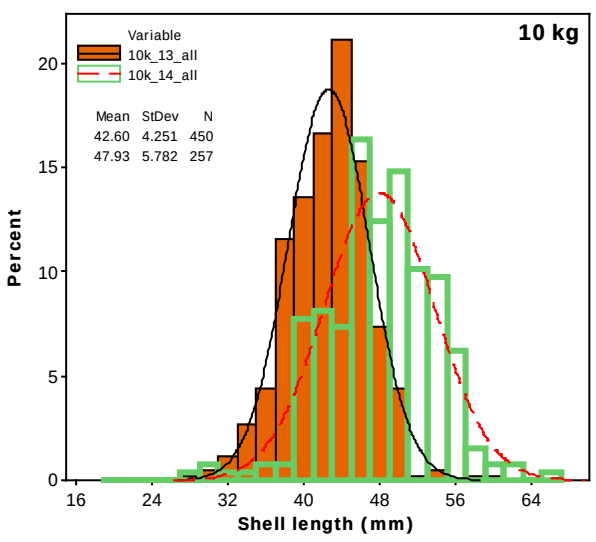
a. Morphometry (morph): A sample of ~150 mussels was collected and shell length (SL mm) and shell width (SW mm) and shell height (SH mm) were recorded for each individual. In the laboratory total fresh weight (TFW g), flesh wet weight (FWW g) and flesh dry weight (FDW g). FDW was obtained by drying the flesh of the mussels for 3 days at 80ºC.
b. Condition Index (CI): CI was measured on 50 mussels per sample as $(FDW)^3/(SL)^6$

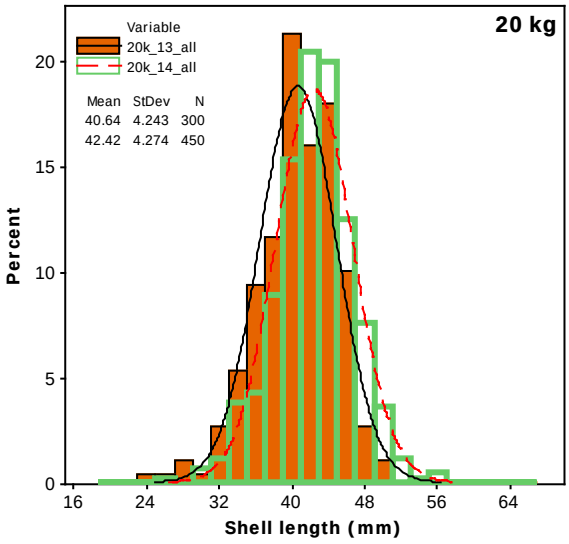
RESULTS AND DISCUSSION

Only results from phase 2 are presented in this section.

PERCENTAGE SHELL LENGTH FREQUENCY

The distribution shell length of the mussels was different between the mussels from different origin from experiment 2. From Figure 3, it seems that mussels in the 10kg treatment grew larger than mussels in the two other treatments after 1 year, nevertheless the mean size in June 2013 (2 months after relay) was already higher than the mean size of the two other treatment later in the year (7 months after relay).





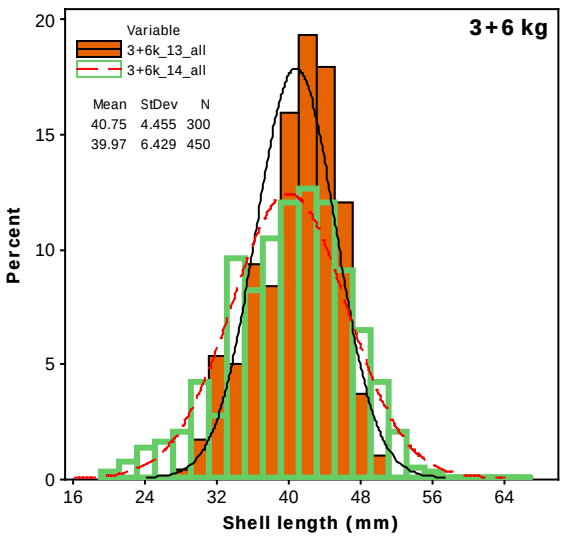


Figure 3. Histogram of shell length distribution for the three different treatments at the beginning (2013) and the end of the experiment (2014).

Although, 10kg mussels were measured in June 2013 while 20 and 3+6kg mussels were only measured in December 2013 therefore it was not compared. The shell length at the end of the experiment was larger for the 10kg treatment than the two others, being, 10 kg > 20 kg > 3+6 kg (Mood median test $X^2 = 138.74$, $p \leq 0.001$). Figure 3 seems to indicate that in the 3+6kg treatment, new recruitment (16-32 mm) occurred, which is probably biasing the mean shell length of this treatment toward a lower median shell length.

CONDITION INDEX

In experiment 2: CI for mussel with 10kg treatment was statistically significantly superior to the other treatment and in order, 10kg > 20kg > 3+6kg (ANOVA GLM, data square root transformed, $F_{399} = 39.03$, $p \leq 0.001$ residuals normally distributed) (Figure 4).

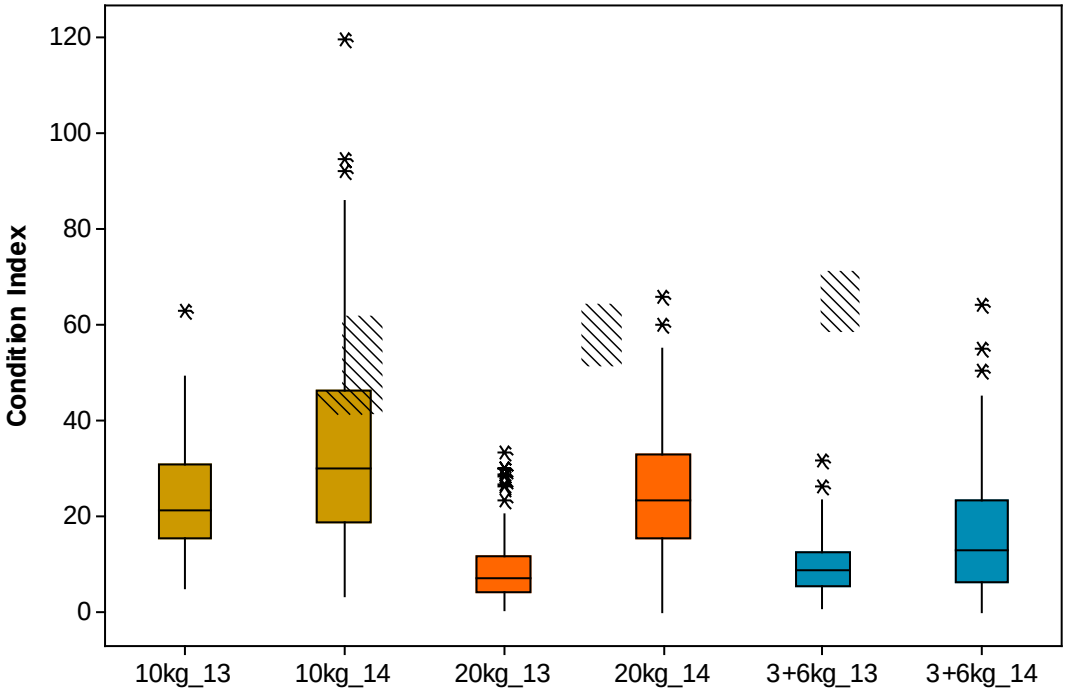
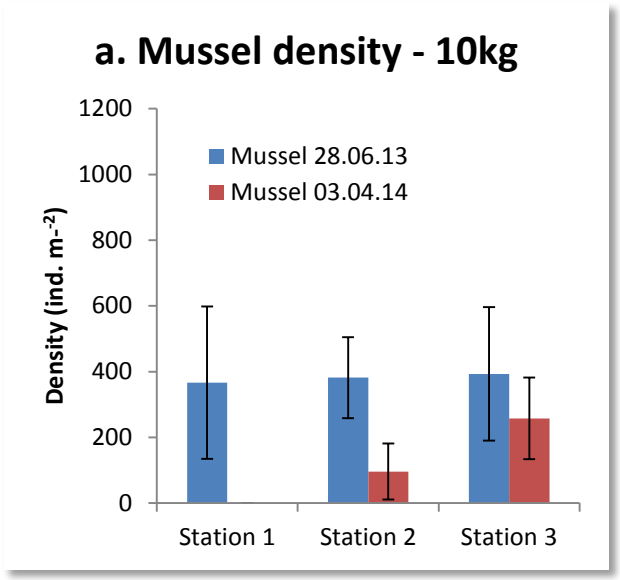
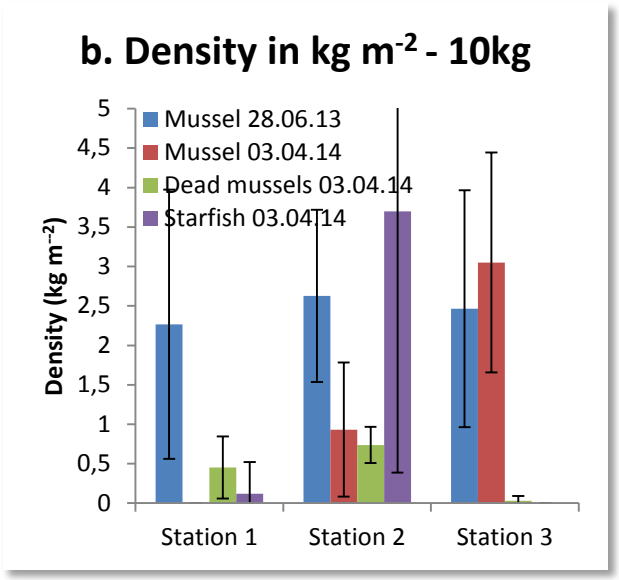


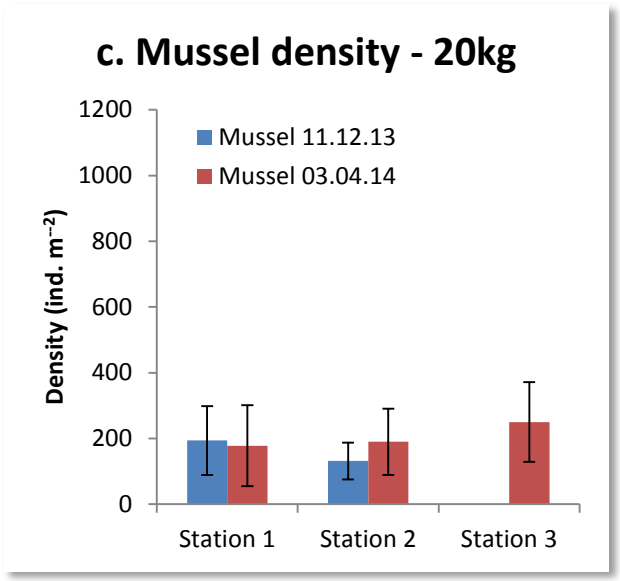
Figure 4. Condition Index (CI) for the 3 different relaying treatments in 2013 and in April 2014.

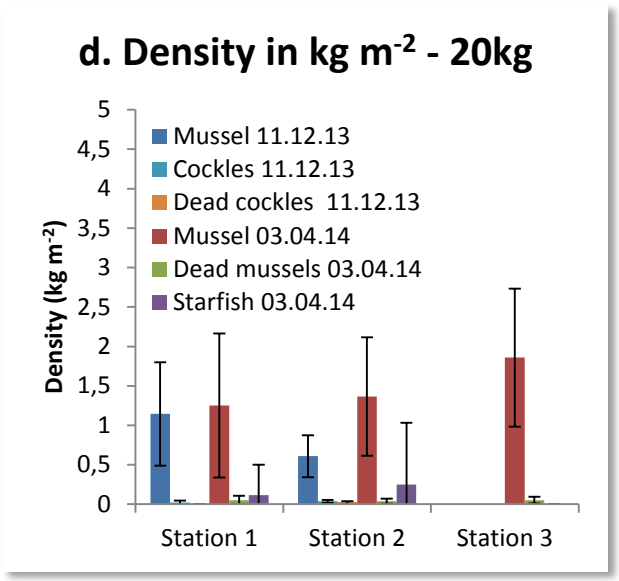
MUSSEL DENSITY AND SAMPLE DISTRIBUTION

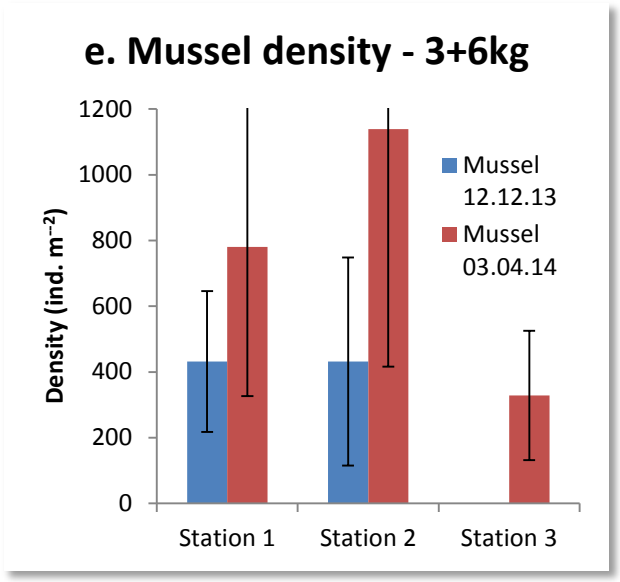
Experiment 2: The mussel density graphs are presented in Figure 5; In the 10kg treatment, the amount of mussels was lower in 2014 than in 2013 ($T_{35} = 4.3$, $p \leq 0.001$) but in term of weight, there was no significant difference between the samples ($T_{37} = 0.95$, $p = 0.346$). The two other treatments expressed the opposite relationships: the density were not significantly different between the two sampling date (20kg: $T_{33}=-0.97$, $p = 0.341$; 3+6kg, 1/sqrt transformed $T_{46} = 1.7$, $p = 0.096$), but the density in term of weight was higher in 2014 for 20kg ($T_{37} = -2.33$, $p = 0.026$) and lower for 3+6kg (1/sqrt transformed $T_{39} = 2.63$, $p = 0.012$). It is noticeable that there was the presence of starfish in 2014 for the 10kg treatment, (Figure 5b) and the presence of recently dead mussels from the starfish predation (large biomass of starfish). This explains the reduction in the number of mussels, but an increase in the weight and condition index of the animals.











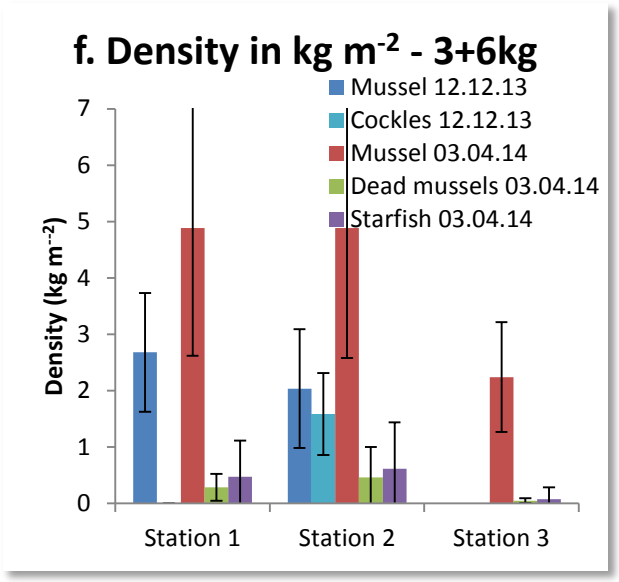
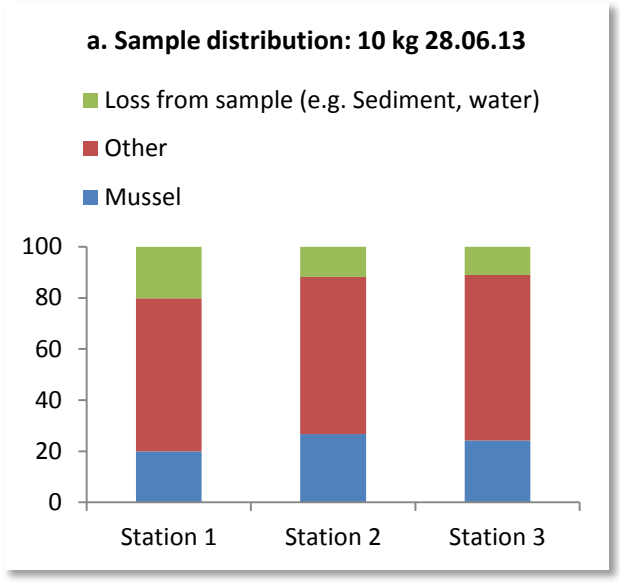
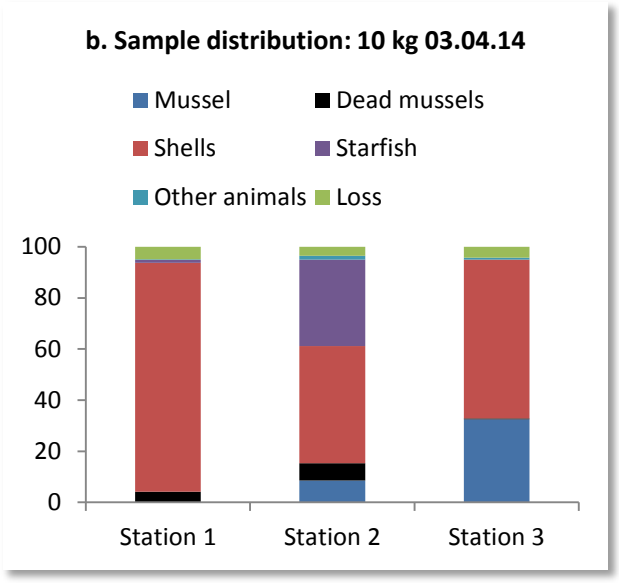


Figure 5. Mussel density in individual m^{-2} for each treatment between 2013 and 2014 on the left side, density in kg m^{-2} for the main categories of sampled items on the right side for the 3 sampled station within a treatment.

The 20kg treatment, presented the particularity in 2014 of a noticeable presence of cockles in the sample, some starfish and recently dead mussels (Figure 5c) indicating the potentiality of starfish predation, and competition for the food resources between the mussels and the cockles. This is also the case for station 3+6kg, a large presence of cockles, and some starfish (Figure 5f).

Figure 6 also complete the information on the mussel distribution in function of the other items (animals, dead shells, loss). The comparison between Figure 6a and Figure 6b for the 10 kg treatment shows that the heavy predation of starfish removed the live mussels in station 1 and left the position with empty shells. The sample distribution for the treatment 20kg is similar between the 2 sampling dates at around 8% with 85% of empty shells (Figure 6c and Figure 6d). For the 3+6kg treatment, while the mussel weight was around 25% of the total weight of the sample in 2013, it reaches up to 40% of the total weight in 2014. Nevertheless, there was the presence of starfish and recently dead mussel in two of the positions of this treatment.





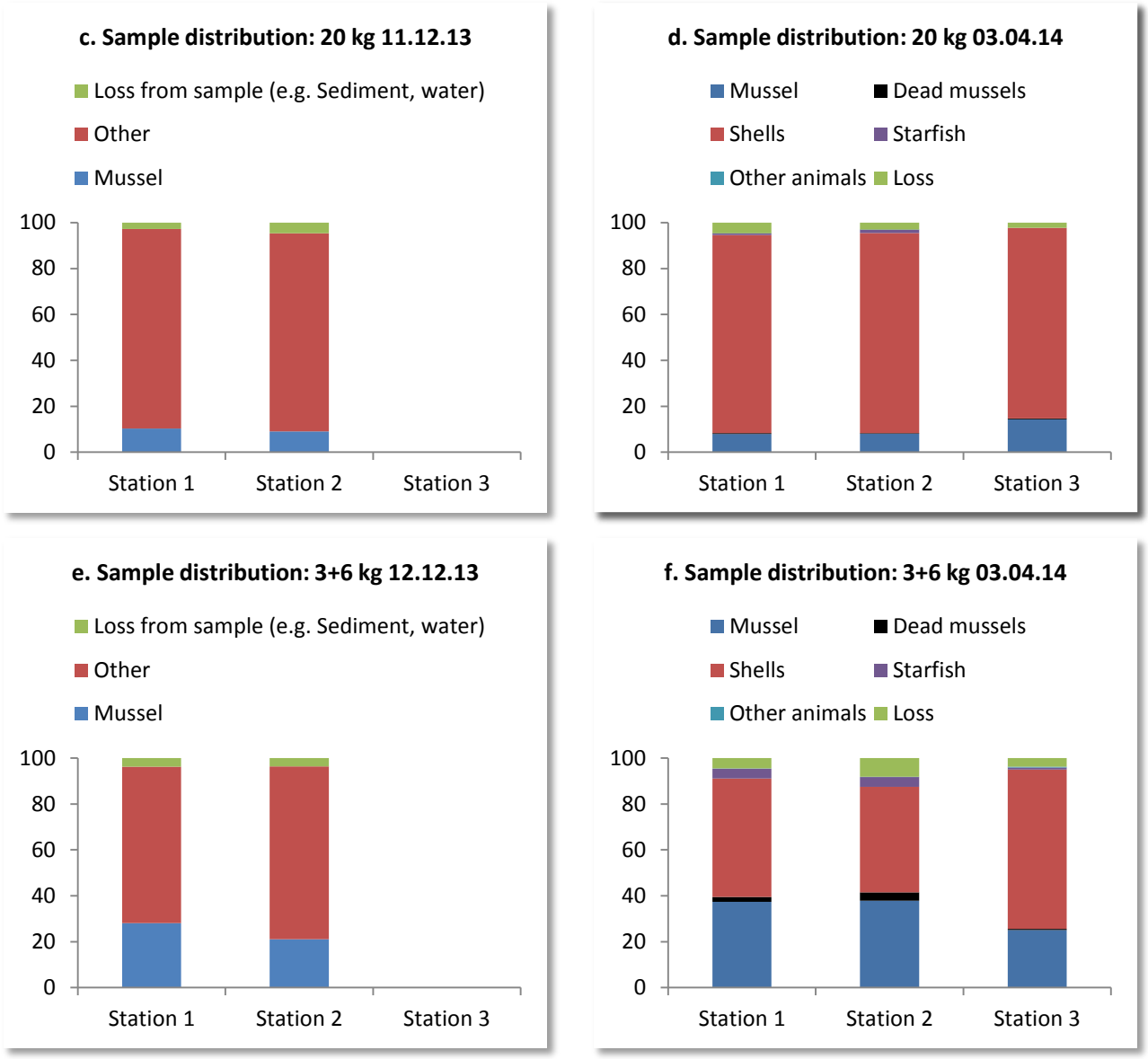


Figure 6. Sample distribution in percent of weight, left side in 2013 and right side in 2014 for the three stations within each treatment.

VIDEO RECORDING

Figure 7 shows the different pictures extracted from the video recording at the three different treatment locations in both 2013 and 2014. The 10 kg treatment clearly shows that there are many empty shells. The videos recording for the 20kg treatment also clearly show the high density of cockles within the mussel beds. The 3+6kg treatment show the very large presence of sediment, in 2013, mussels are half buried in the sediment, while in 2014, only the siphons are visible.

28.06.13 10kg

03.04.14 10kg position 1

11.12.13 20kg

03.04.14 20kg position 1

11.12.13 3+6kg

03.04.14 3+6kg

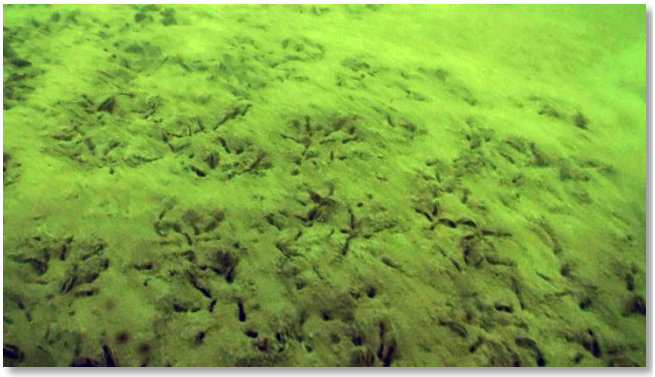
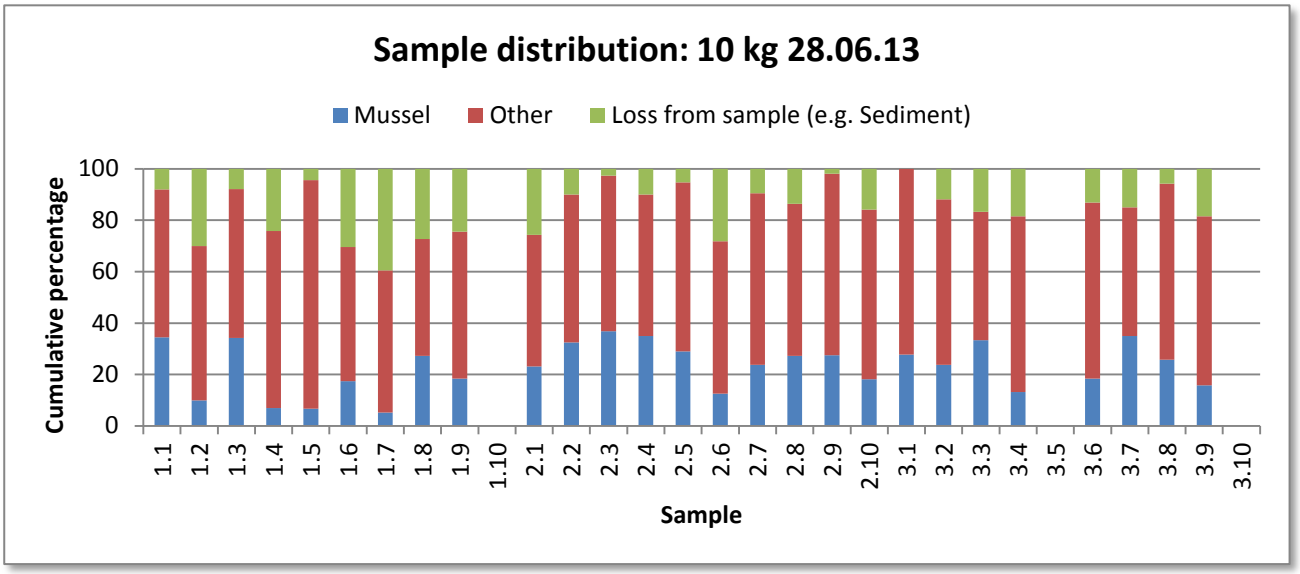


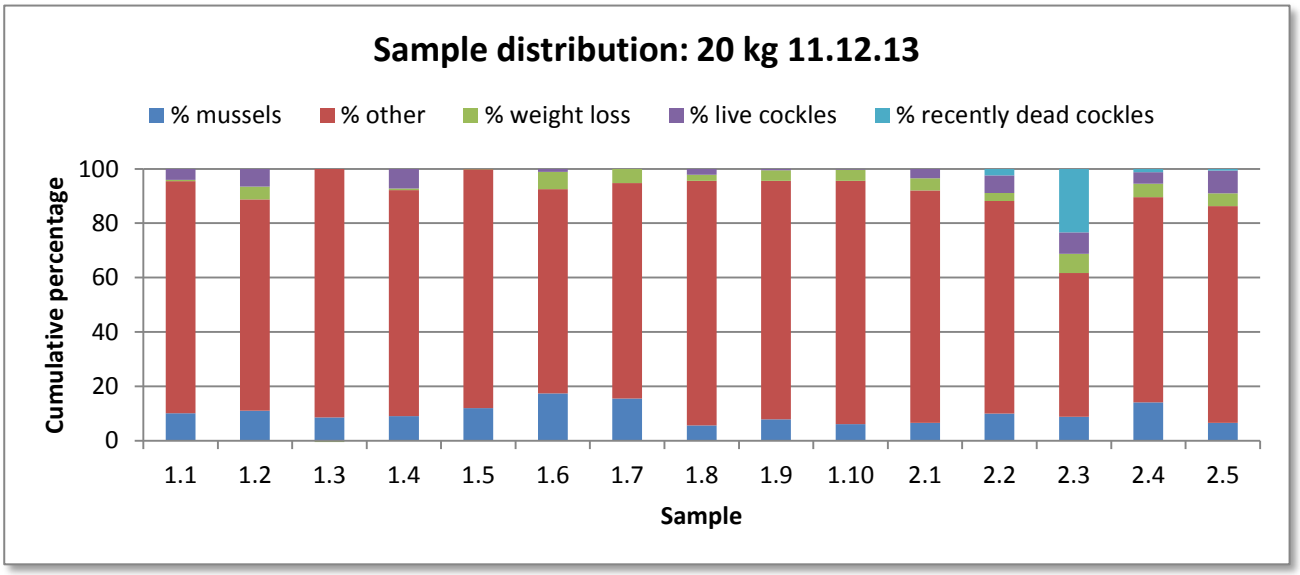
Figure 7.Photo captures at the three different treatment locations in 2013 and 2014.

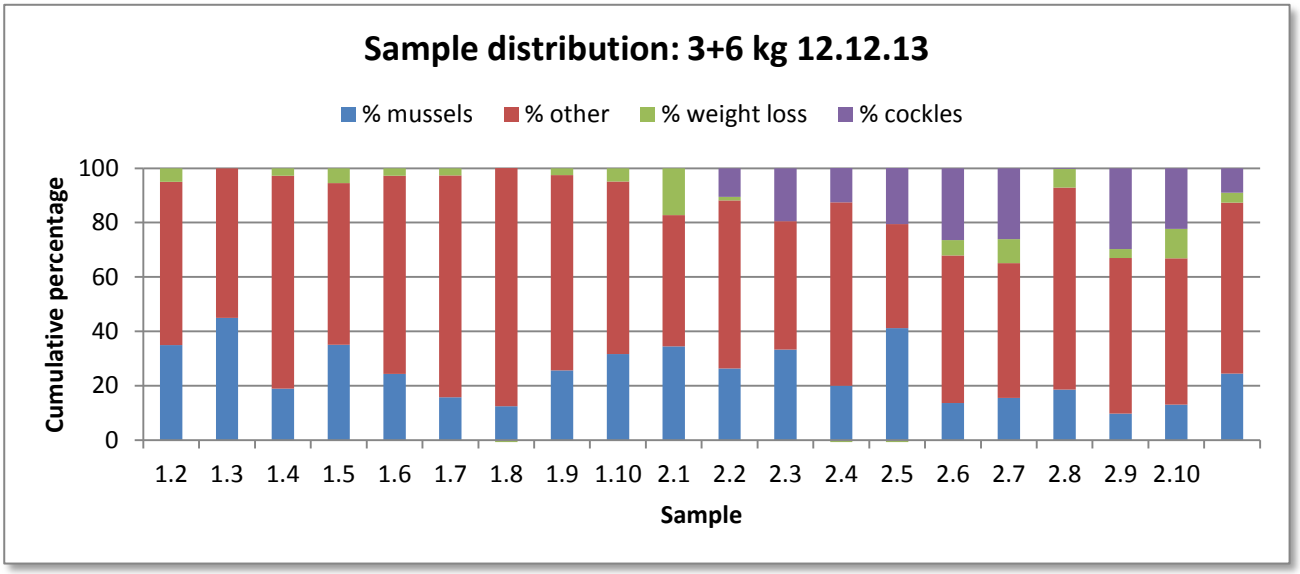
CONCLUSIONS

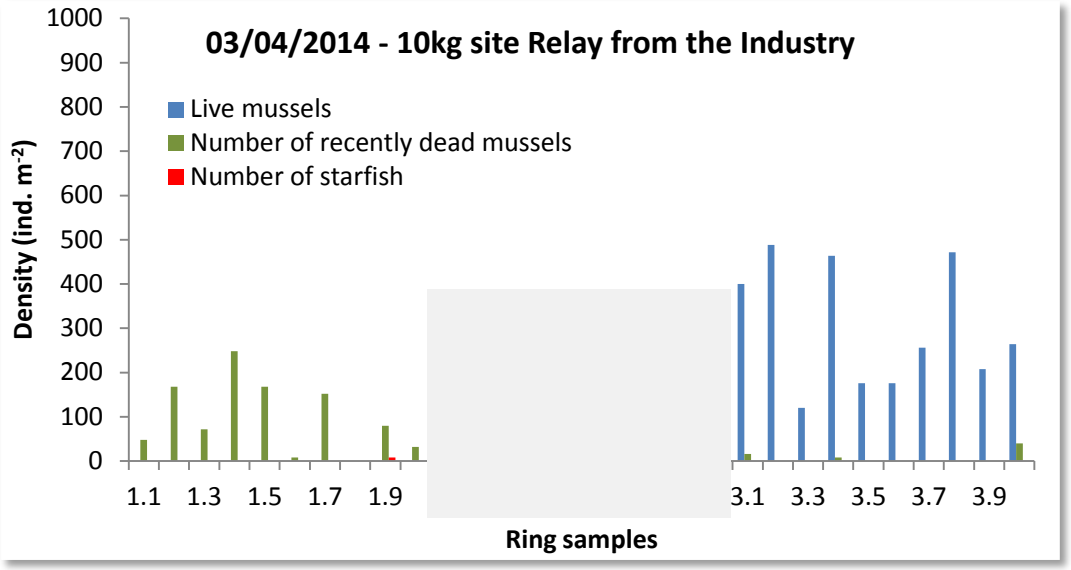
The three different treatments in experiment 2 show different results. From a growth point of view, it seems that mussels with the 10kg treatment were bigger (Shell length) and grew bigger than the other treatments; Their condition index was also statistically significantly superior that the two other treatments. Heavy starfish predation is a big issue for bottom mussels; it annihilated the entire mussel population in one of the station in 2014 for the treatment 10kg. The sample distribution indicated that less than 20-40% of the bed in term of weight is mussel biomass. The rest was composed mainly of empty shells (50 to 80%). There was a mix of cockle and mussels in treatment 20kg and for the 3+6 kg, the substratum looked very different than for the other treatments, where mussels were almost buried into the sediments.

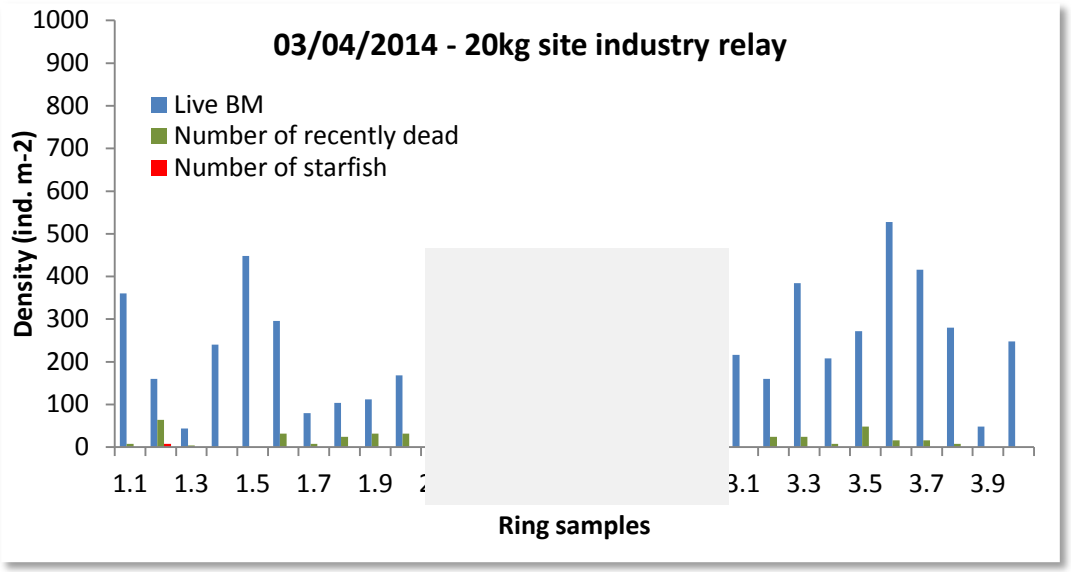
EXTRA material

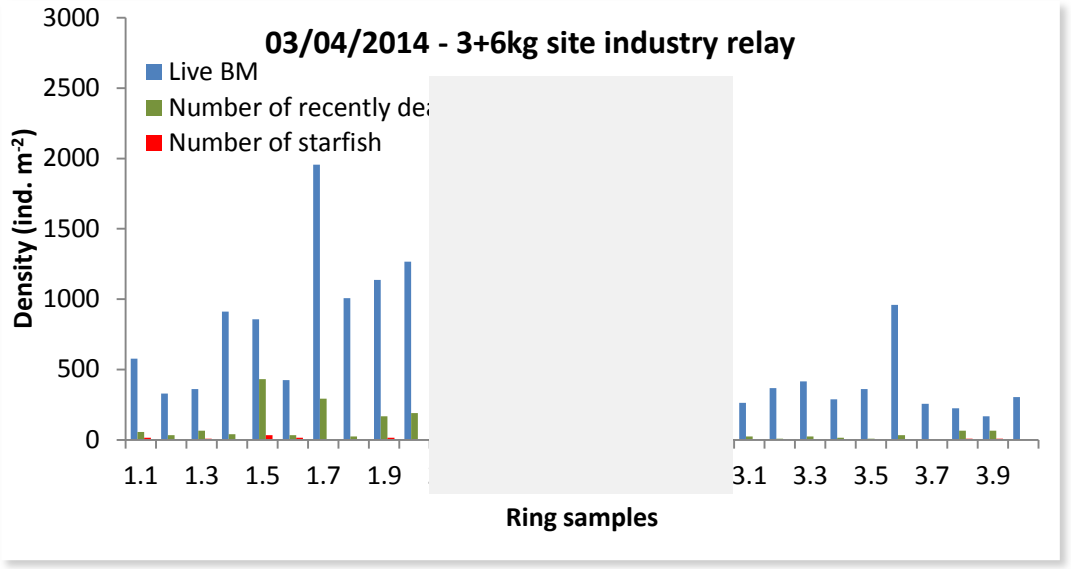







03/04/2014 - 10kg site Relay from the Industry
Live mussels
Number of recently dead mussels
Number of starfish
Density (ind. m-2)
1000
900
800
700
600
500
400
300
200
100
0
1.1
1.3
1.5
1.7
1.9
3.1
3.3
3.5
3.7
3.9
Ring samples


03/04/2014 - 20kg site industry relay
Live BM
Number of recently dead
Number of starfish
Density (ind. m-2)
1000
900
800
700
600
500
400
300
200
100
0
1.1
1.3
1.5
1.7
1.9
3.1
3.3
3.5
3.7
3.9
Ring samples


03/04/2014 - 3+6kg site industry relay
Live BM
Number of recently dea
Number of starfish
Density (ind. m-2)
3000
2500
2000
1500
1000
500
0
1.1
1.3
1.5
1.7
1.9
3.1
3.3
3.5
3.7
3.9
Ring samples