ECsafeSEAFOOD

Priority environmental contaminants in seafood: safety assessment, impact and public perception

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Deliverable D2.10

Effect of origin on level of contamination

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1. Summary

The main objective of this deliverable was to research if the levels of persistent contaminants such as Arsenic, mercury, brominated flame retardants (BFRs), perfluoralkylsubstances (PFAS) and Polycyclic aromatic hydrocarbons (PAHs) in seafood species are affected by origin. Most species were monitored twice. The approach followed was first to focus on contaminants levels above the method limits of quantification (>MQL), second to plot out the contaminants levels in species available from different locations. This has been performed with wet weight concentrations measured in both commercial sampling carried out within the project named round 1 (R1; 2014) and round 2 (R2; 2015).

For many species, the effect of location was clear; the pollution level of the environment was shown in the levels of contaminants in the Seafood. The results of analysis were also influenced by the two different monitoring rounds.

2. Introduction

In this project, the contaminant levels were analysed in a wide variety of seafood samples. The complete list of analysed species and contaminants, as well as the observed levels, are clearly described in Deliverable 2.4 Presence and levels of priority contaminants in seafood. In this report, the influences of the origin of seafood species on the observed levels were to be investigated. Next to species dependent accumulation, the environment has a very large effect on the contaminant levels in the seafood species.

To determine these effects, a proper set of samples as well as properly defined levels of contaminants are required. In many cases the levels of contaminants in seafood species were too low to be quantified properly. The influence of the origin on the levels could therefore not be determined for all contaminants analysed. Still, large differences in levels were observed, depending on species and the location where they were sampled. Not all seafood species have been analysed from different locations, or are from unknown origin (e.g. canned fish). Some of these results are shown to illustrate the range of levels that can be observed within seafood originating from over the world.

2.1. Inorganic Arsenic (iAs):

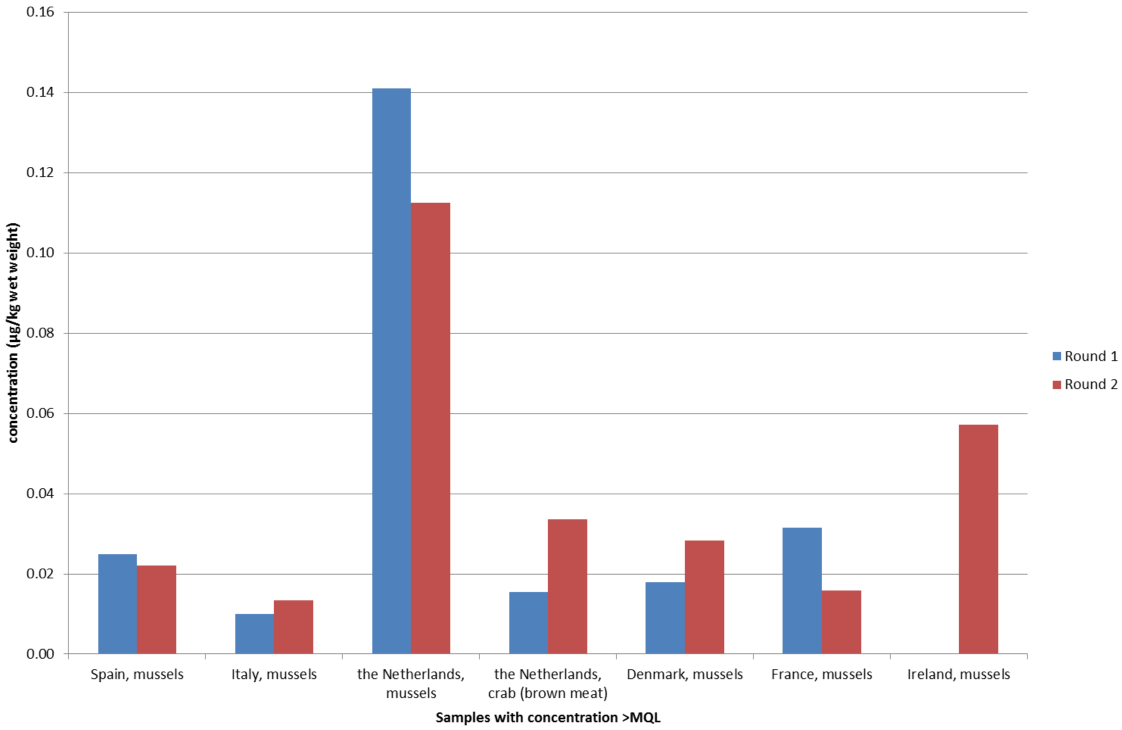

Figure 1. Inorganic arsenic (iAs) in samples of mussels from different origins at sampling round 1 and 2

A clear effect of origin was detected in mussel samples from round 1 and 2 (Figure 1). The highest levels were found in Dutch mussels, where levels were twice as high as those found in mussels from Ireland which contained the second highest levels. The brown crab is shown also in this Figure 1, it was sampled at roughly the same location in Round 1 and 2, but the crabs were pooled from a large area.

2.2. Total Mercury (T-Hg) and methyl-mercury (MeHg)

The origin has a clearly effect on T-Hg and MeHg levels in mackerel (Figure 2). While mackerel from Italy showed the highest absolute contamination level on MeHg and T-Hg; mackerel from Spain presented the highest relative level of MeHg. The canned mackerel, although origin unknown, is included to show that the levels are within the range of the other analysed mackerel.

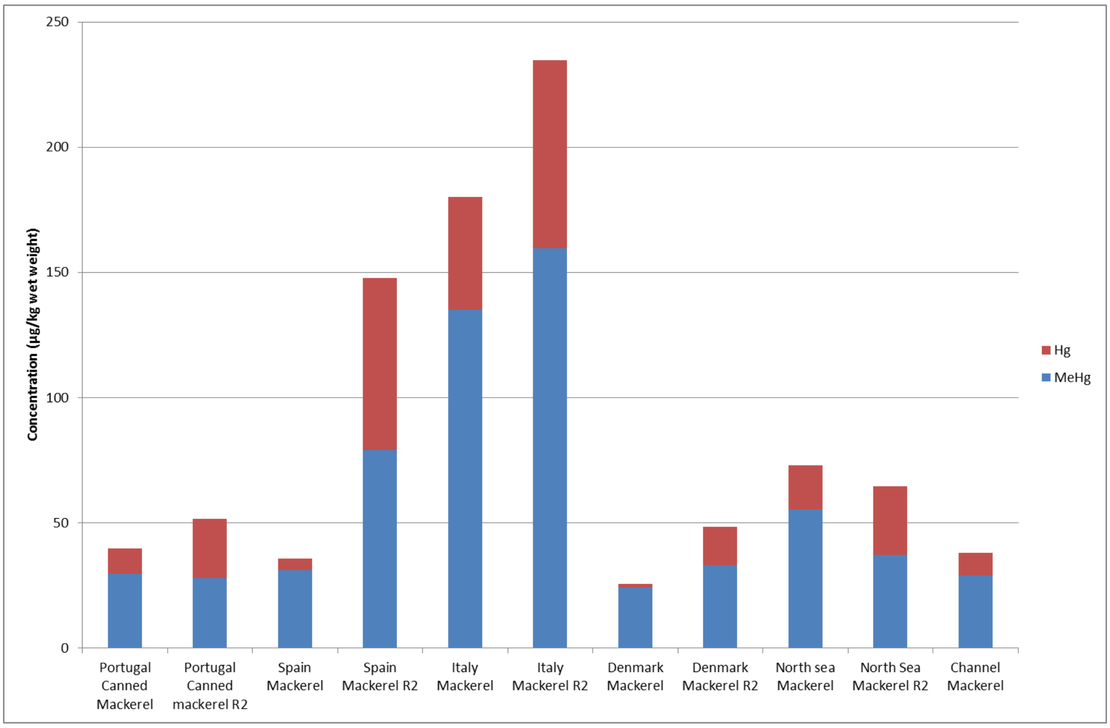

Figure 2. Levels of total mercury (T-Hg) and methyl-mercury (MeHg) in mackerel from different origins at sampling round 1 and 2 (R2)

Concerning the flatfish samples, an effect of the origin on the T-Hg and MeHg levels was also observed (Figure 3). Sole from Italy and the Mediterranean presented lower levels of mercury than plaice from the Channel and North Sea, regardless the size and sampling period.

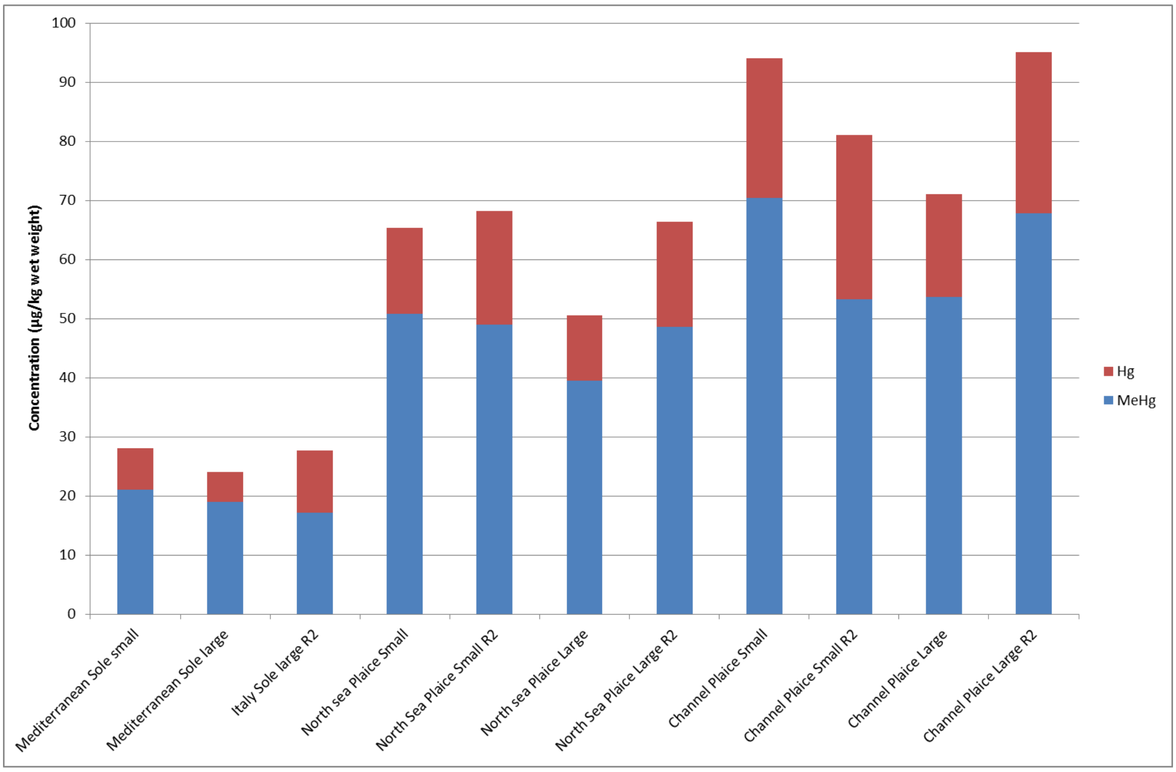

Figure 3. Levels of total mercury (T-Hg) and methyl-mercury (MeHg) in flatfish samples from different origins at round 1 and 2 (R2)

The effect of origin in T-Hg and MeHg contamination levels is also clear in other species. Figure 4 clearly shows the wide range of mercury levels in seafood, clearly both origin and species dependent.

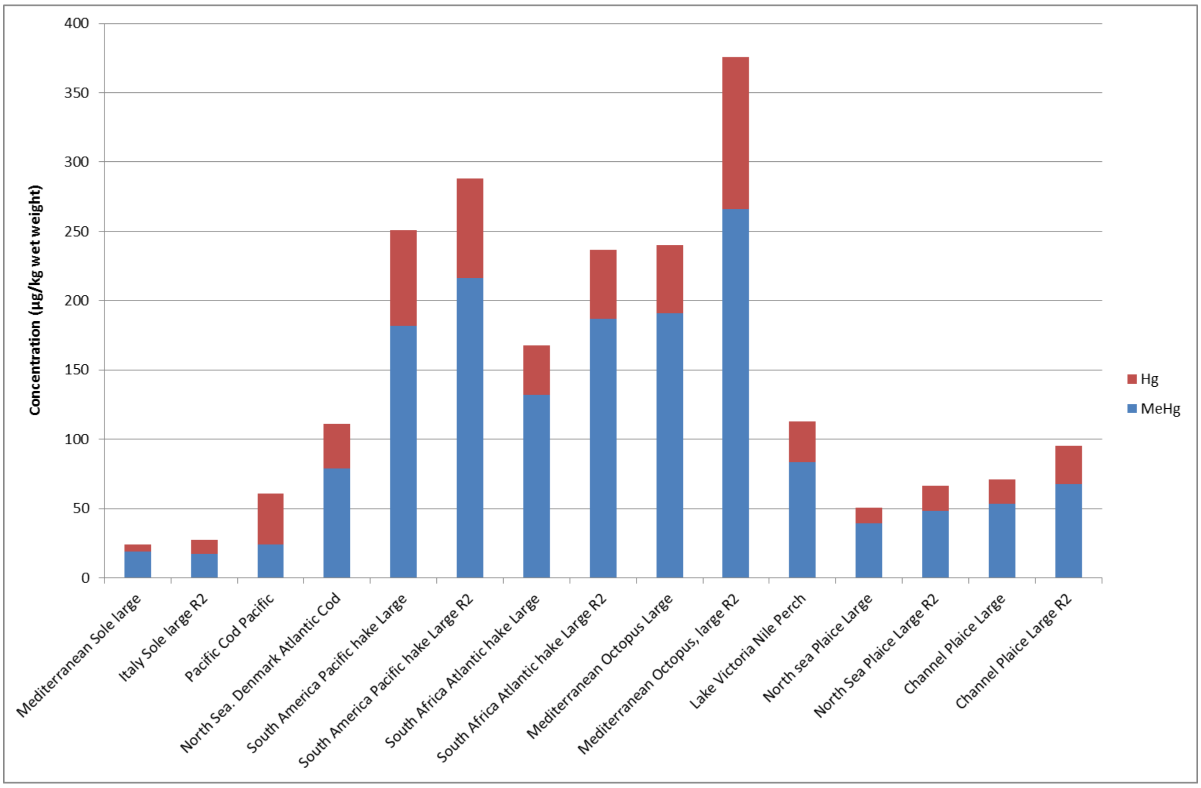

Figure 4. Levels of total mercury (T-Hg) and methyl-mercury (MeHg) in samples from all over the world in sampling round 1 and 2 (R2)

Some species have only been sampled from one origin (e.g. Octopus and Nile Perch), they have yet been incorporated in figure 4 to show the full range of mercury levels that can be observed in commercially available seafood.

Conclusions:

- Origin has clearly an influence on mercury level, but at the same time the type of species, and size, can have an effect too.

2.3. PBDEs:

Very large differences were observed between levels in mackerel from different locations (Figure 5). But the effect of season (Round 1 versus round 2) was also unexpectedly high at some locations. While in round 1, the highest PBDEs contamination levels where found in North Sea, followed by Italy, Spain and Denmark; in round 2 the highest levels of PBDEs where found in mackerel from Italy, followed by Denmark, Spain and North Sea.

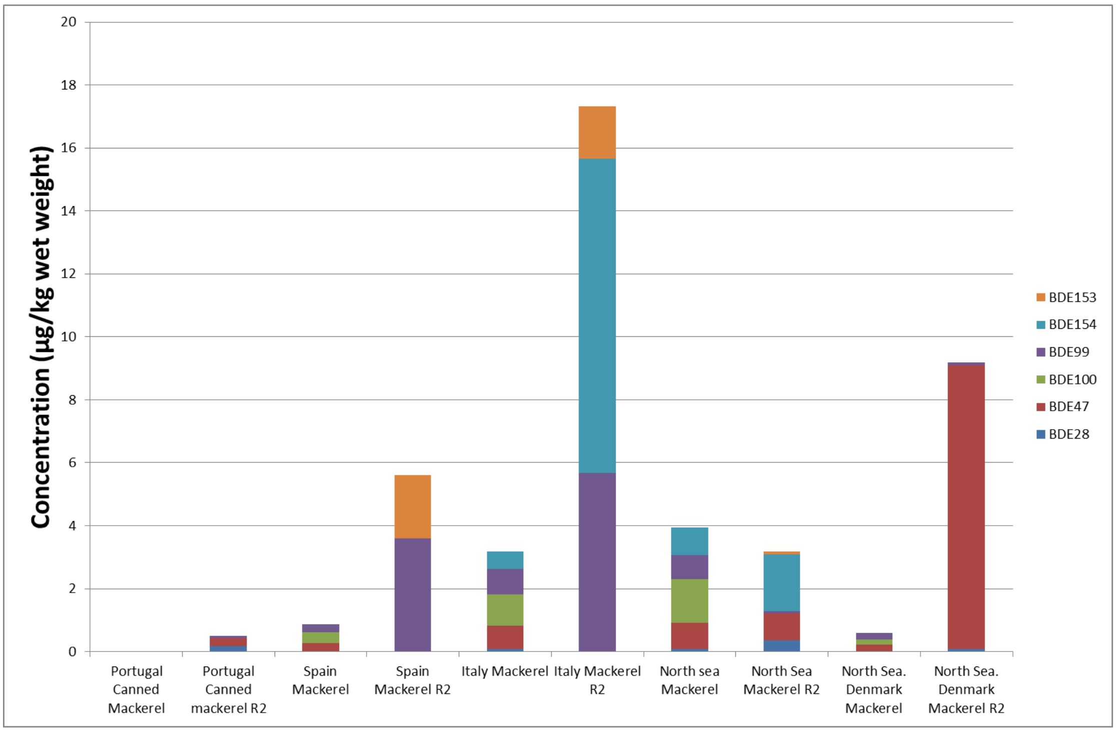

Figure 5. Levels of BDEs in mackerel from different origins at round 1 and 2 (R2)

Once again, large differences were observed as results of origin when mussels were analysed (Figure 6). The variation is as large as with mackerel, but different with respect to the effect of each location, being the highest contamination level found in Italy and the lowest in Denmark.

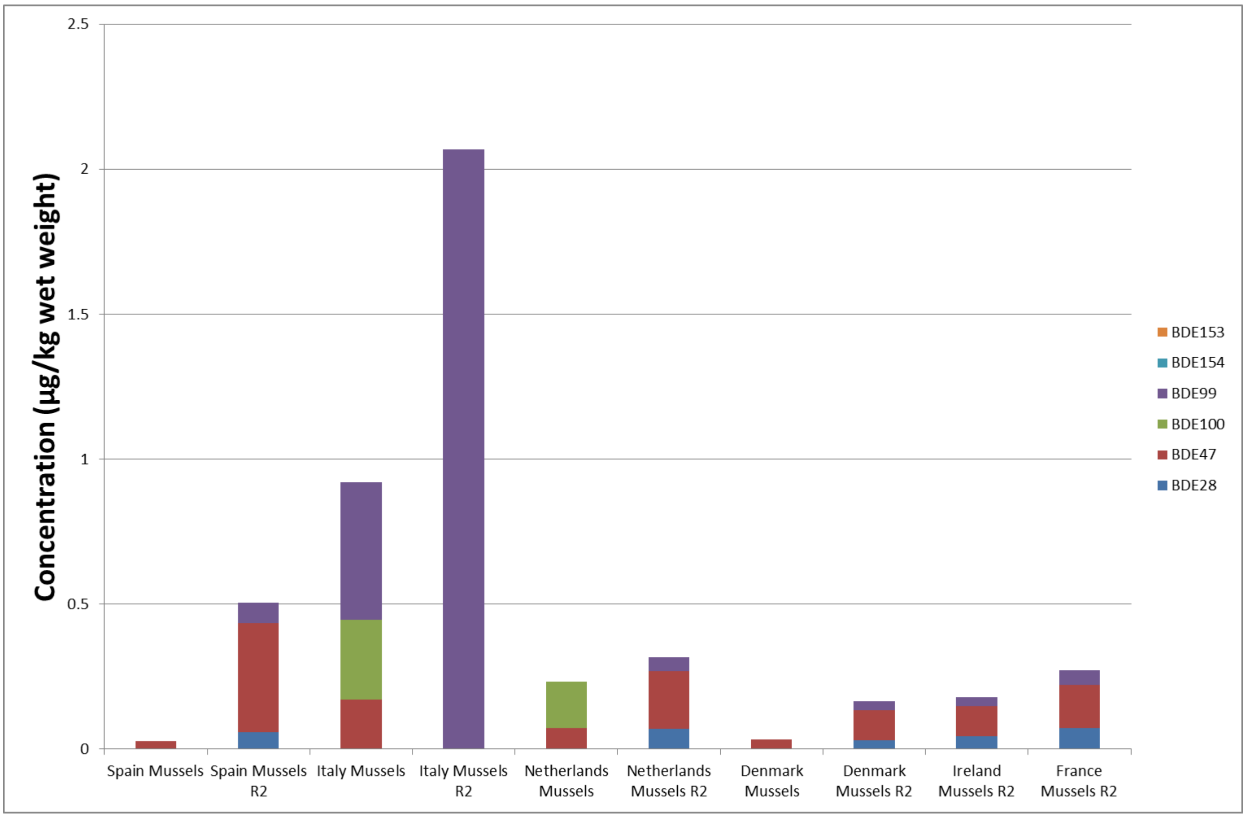

Figure 6. Levels of PBDEs in mussel samples from different origins at round 1 and 2 (R2)

In figure 7, it is also observed that the origin has also significant effect on PBDEs levels in Cod. North Sea samples presented higher contamination levels than the Pacific samples.

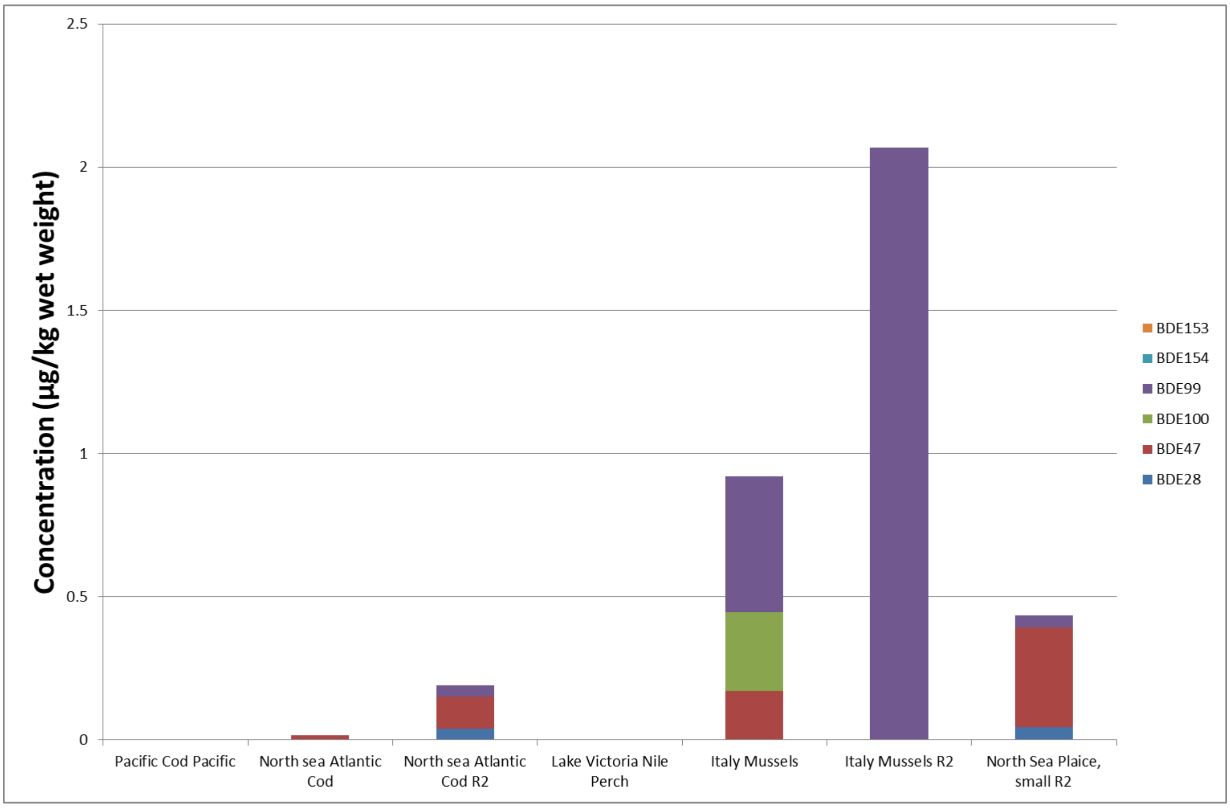

Figure 7. Levels of BDEs in cod samples from different origins at round 1 and 2 (R2)

Figure 7 illustrates, although not all the same species, the large range of PBDE levels that can be observed within seafood. From extremely low levels in cod filet from open sea and in Nile Perch from Lake Victoria to relatively high levels in mussels from Italy.

Conclusions:

-The levels and profiles of PBDEs differ much between location, species and monitoring rounds

-The origin of the species has a clear effect, as does the time of sampling.

2.4 New BFRs:

The levels of the analysed new Brominated Flame Retardants are also influenced by location, North Sea mackerel contains extremely high levels of a-HBCD in round 1. Whereas in round 2 the level is much lower, and other BFRs can be determined (Figure 8).

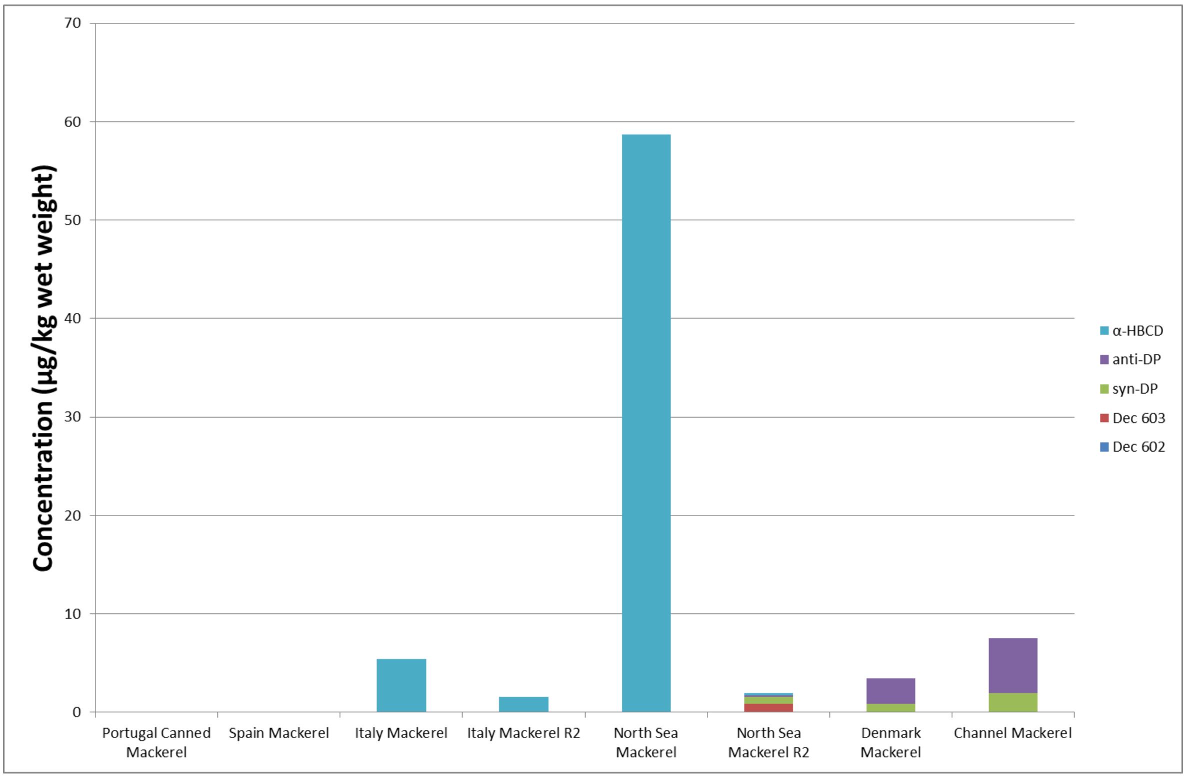

Figure 8. Levels of new BFRs in mackerel from the different origins at sampling round 1 and 2 (R2)

Concerning the HBB levels, the effect of origin, as well as the effect of a different sampling were large, as shown in figure 9.

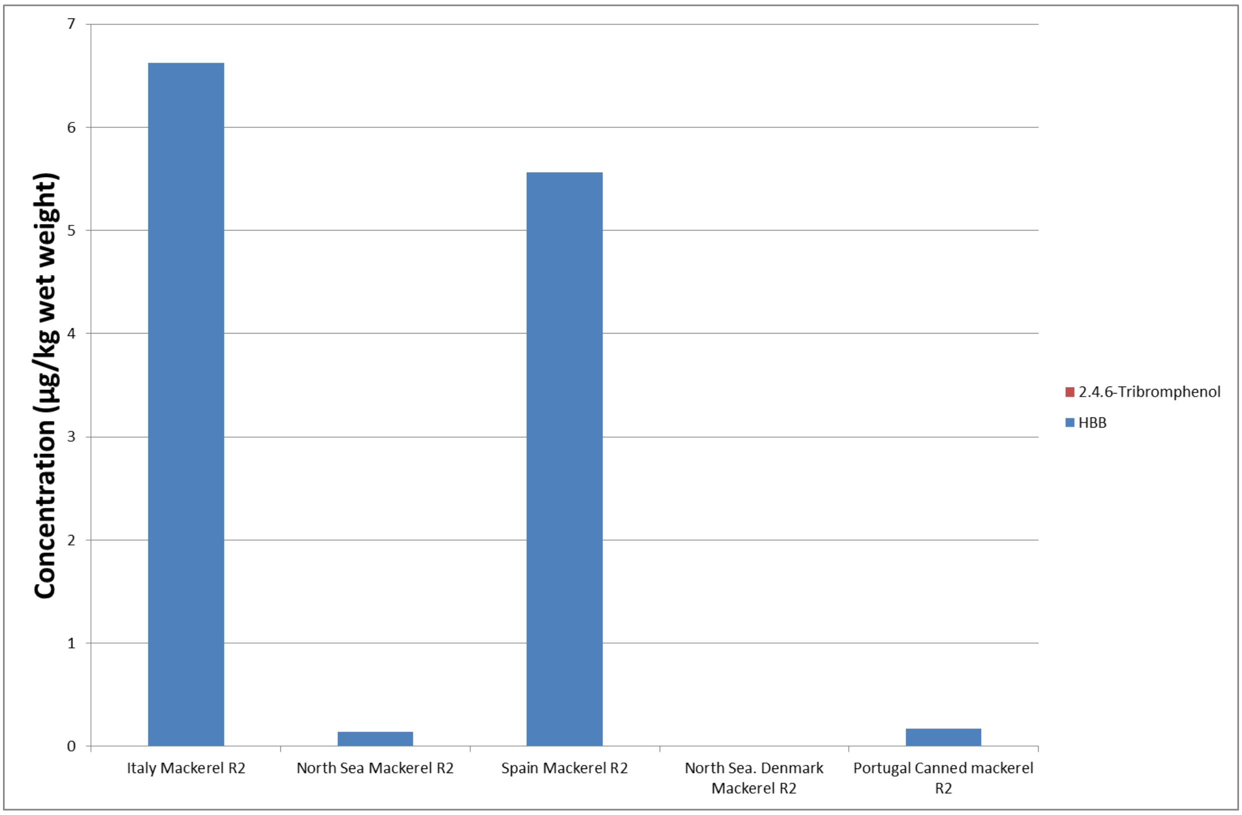

Figure 9 Levels of HBB and Tribromophenol in Mackerel from different origin at sampling round 2

Also, in mussels very large differences in new BFRs levels can be observed, suggesting strong differences in contamination levels between locations (Figure 10). In this case, mussels from Denmark presented the higher contamination levels. As for HBB levels, mussel from Italy presented the highest levels; whereas 2,4,6- Tribromophenol was determined in all mussels with no large differences between locations (Figure 11).

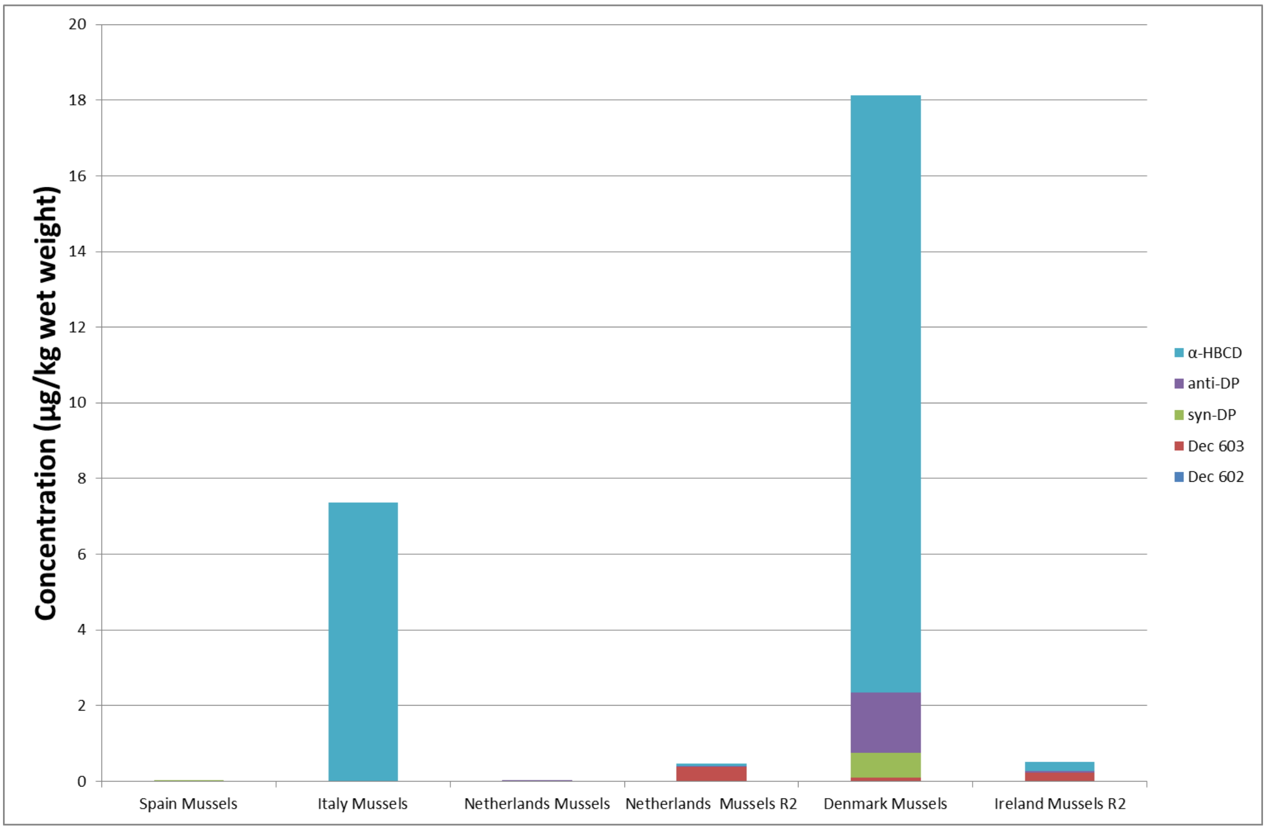

Figure 10. Levels of new BFRs in mussels from different origin at round 1 and 2 (R2)

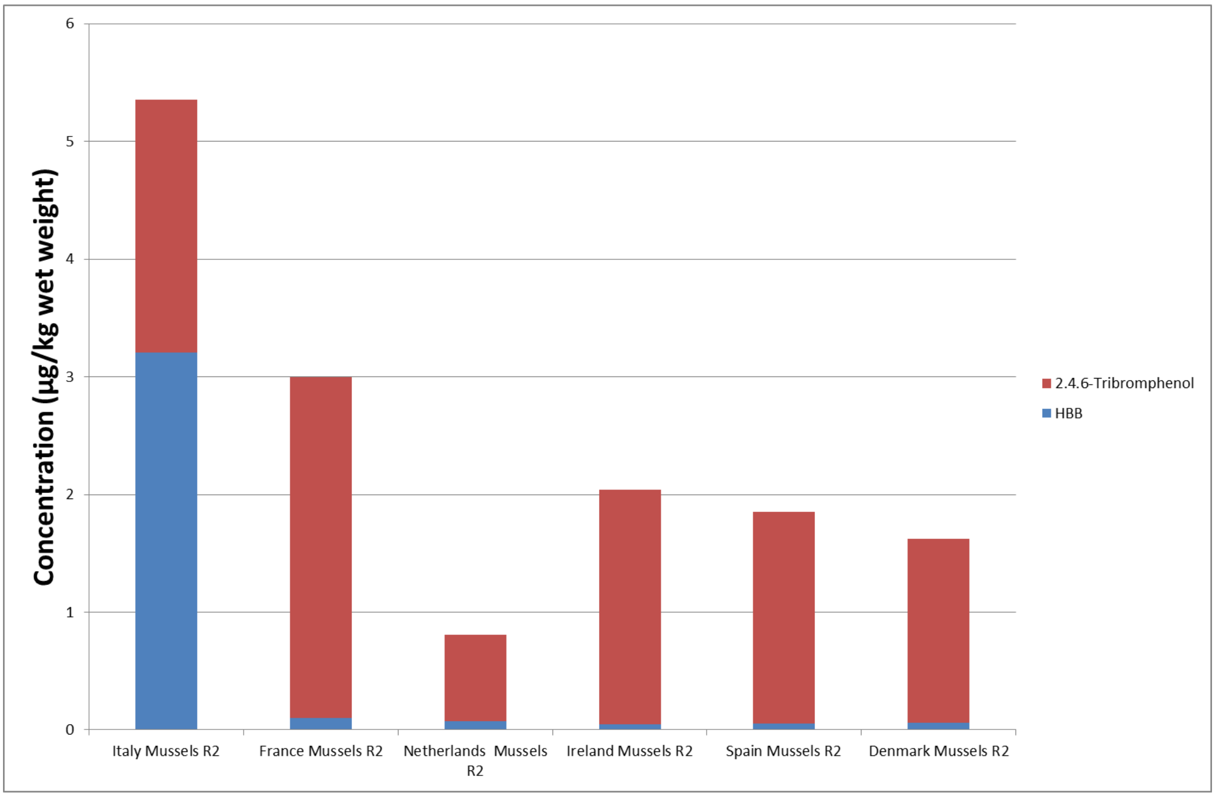

Figure 11. Levels of HBB and Tribromophenol in mussels from different origin at sampling round 2

Figure 12 demonstrates the large differences in levels that can be observed between cod species sampled at different locations. Samples from North Sea presented higher values than samples from Pacific. To illustrate the range of levels, Mussels, Nile Perch and Plaice are also shown in this figure.

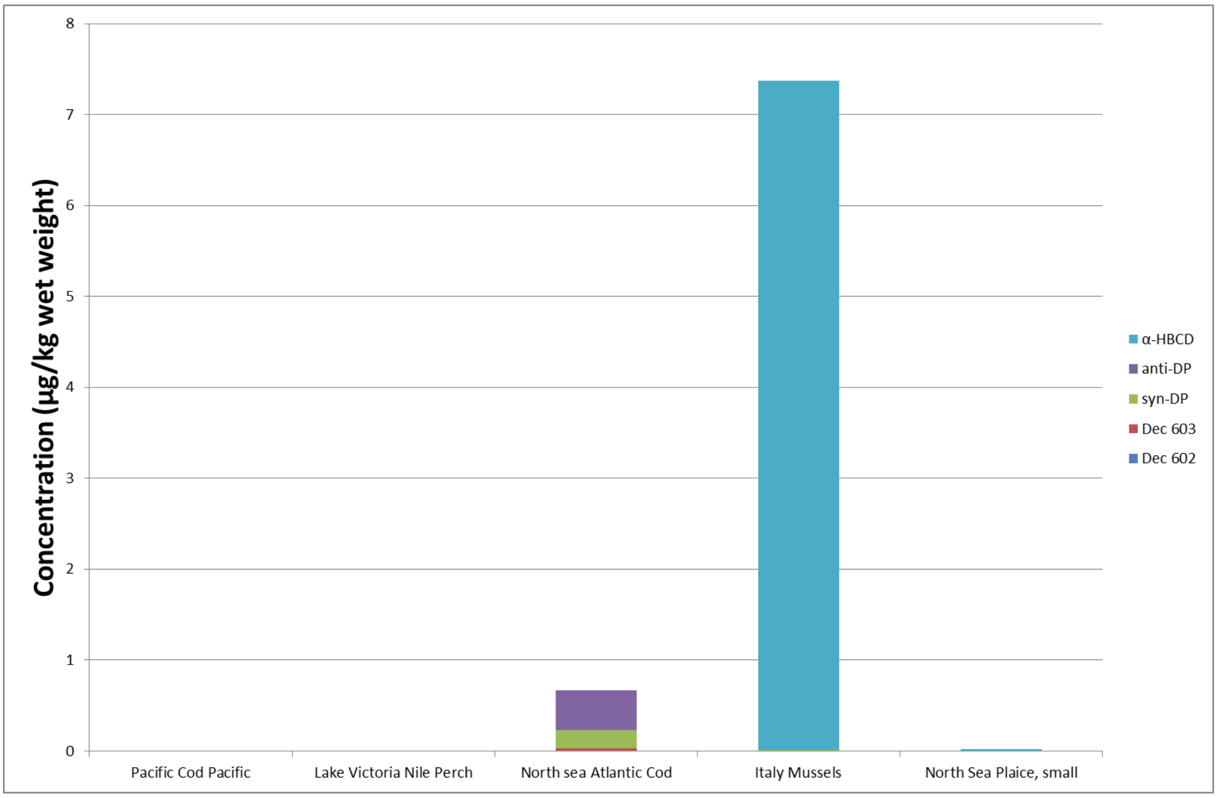

Figure 12. Levels of new BFRs in samples from different origins at round 1

2.5 MBDEs:

The contamination levels of MBDEs in seafood samples are also affected by origin. Although with different compounds of MBDEs, Channel mackerel has the highest contamination level, followed by mackerel from North Sea, Italy and Spain, respectively (Figure 13).

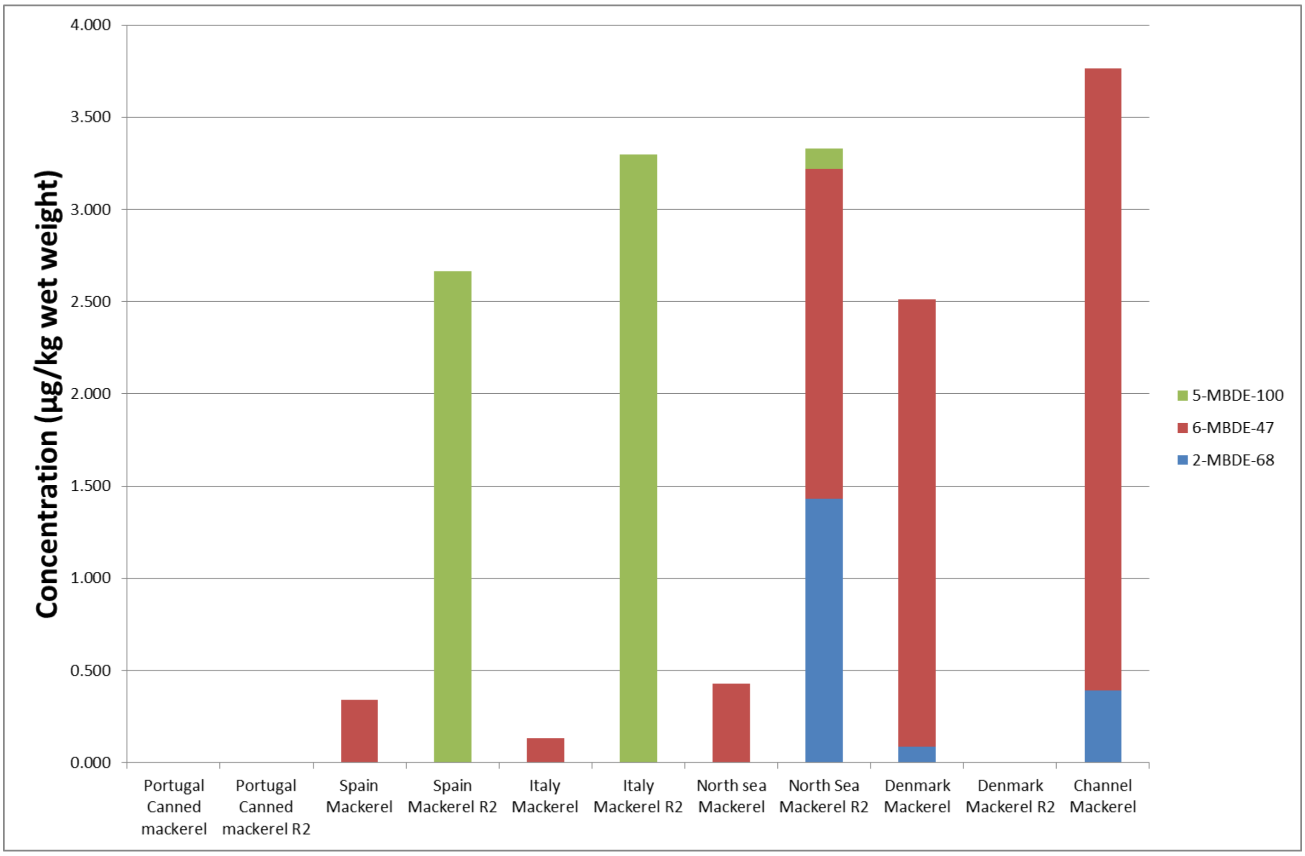

Figure 13. Levels of MBDEs in mackerel from different origins at sampling round 1 and 2 (R2)

Another clear example that levels in seafood are strongly influenced by location and also time of sampling were observed in mussels (Figure 14). Mussels from Italy presented the MBDEs highest contamination level, although dependent on the MBDE congener and sampling season.

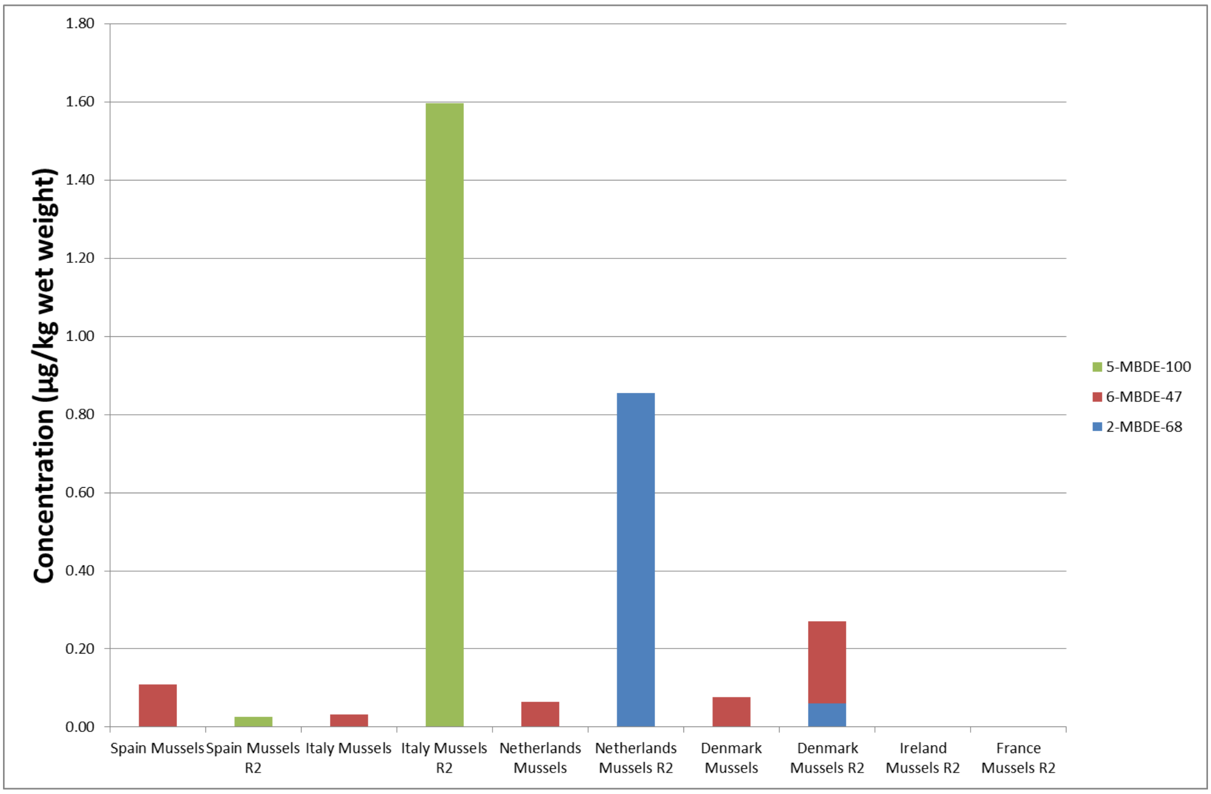

Figure 14. Levels of MBDEs in mussels from different origins at sampling round 1 and 2 (R2)

For cod samples, MBDEs levels were also affected by the origin (Figure 15). When comparing cod samples from Pacific and North Sea, at this last location the contamination levels were higher. To put these levels in perspective, the levels in Nile Perch and mussels from Italy are shown too.

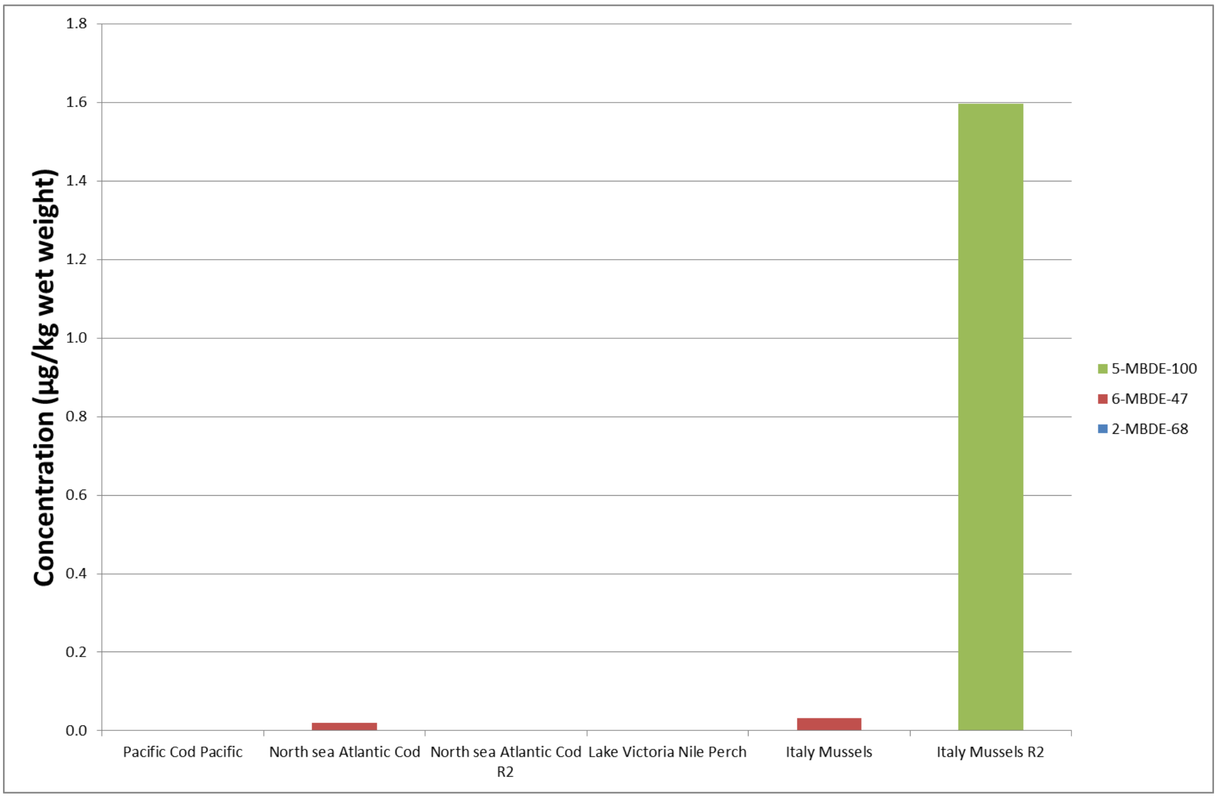

Figure 15. Levels of MBDEs in cod samples from different origin at sampling round 1 and 2 (R2)

2.6 PFCs:

The levels of the analysed PFCs are in general low, and in many occasions below LOQ. The levels of PFCs are also influenced by origin, where mackerel from Spain contains the highest levels in both sampling periods (Figure 16).

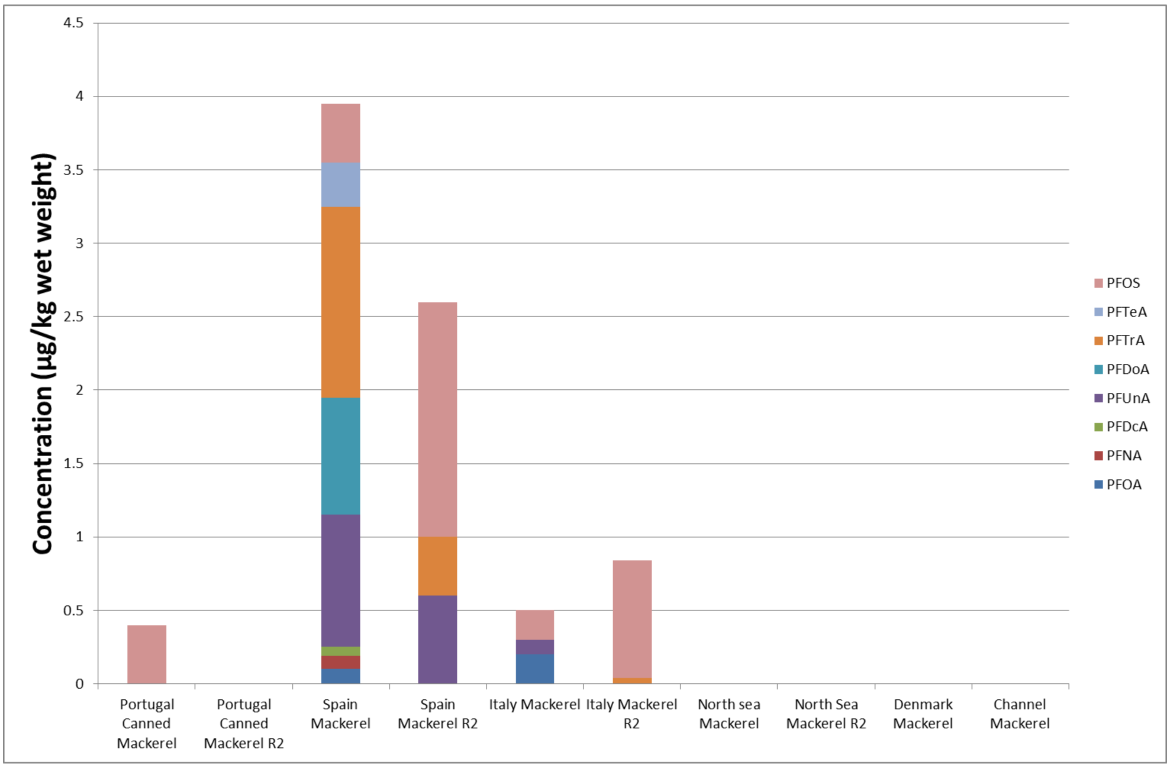

Figure 16. Levels of PFCs in mackerel from different origins at sampling round 1 and 2 (R2)

Moreover, figure 17 show that PFCs composition in Mediterranean sole differs strongly from the composition observed in fish from the North Sea and Channel. On the other hand, mussels from Spain showed higher PFCs levels, as well as a different composition, compared to the other origins (Figure 18).

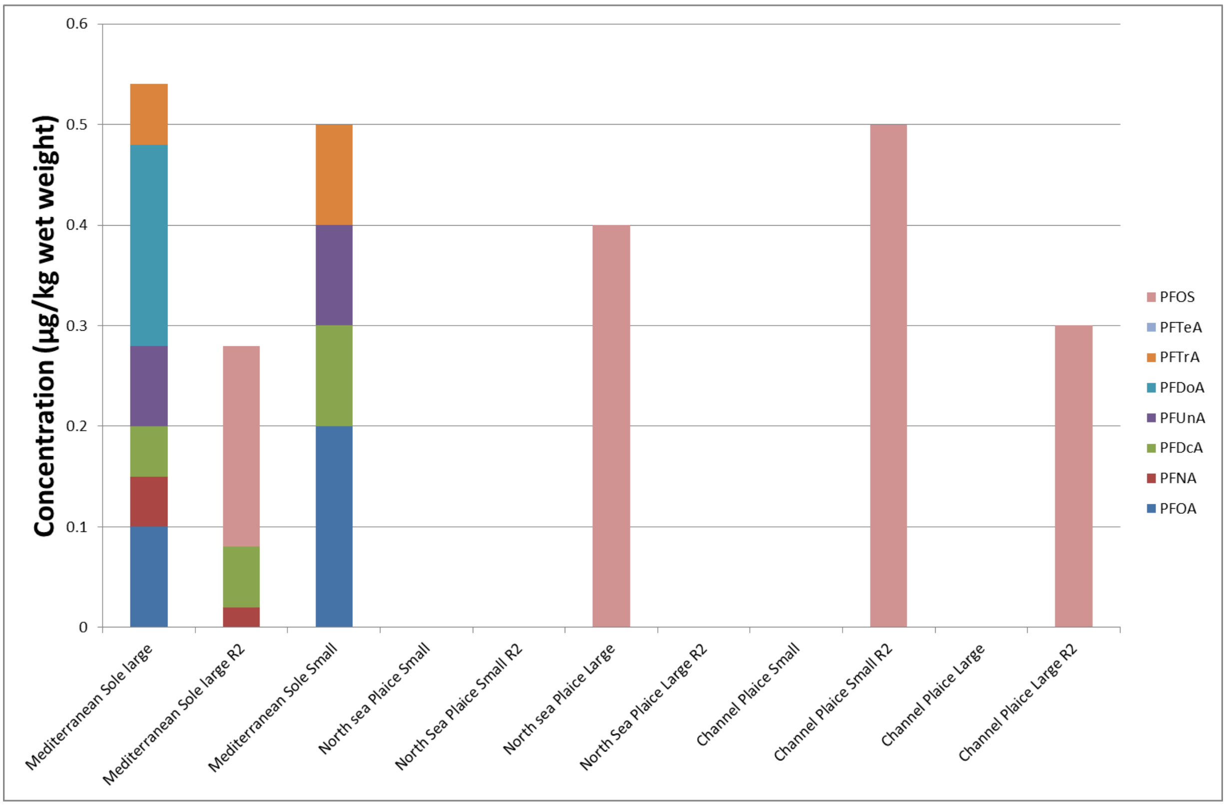

Figure 17. Levels of PFCs in flatfish samples from different origins at sampling round 1 and 2

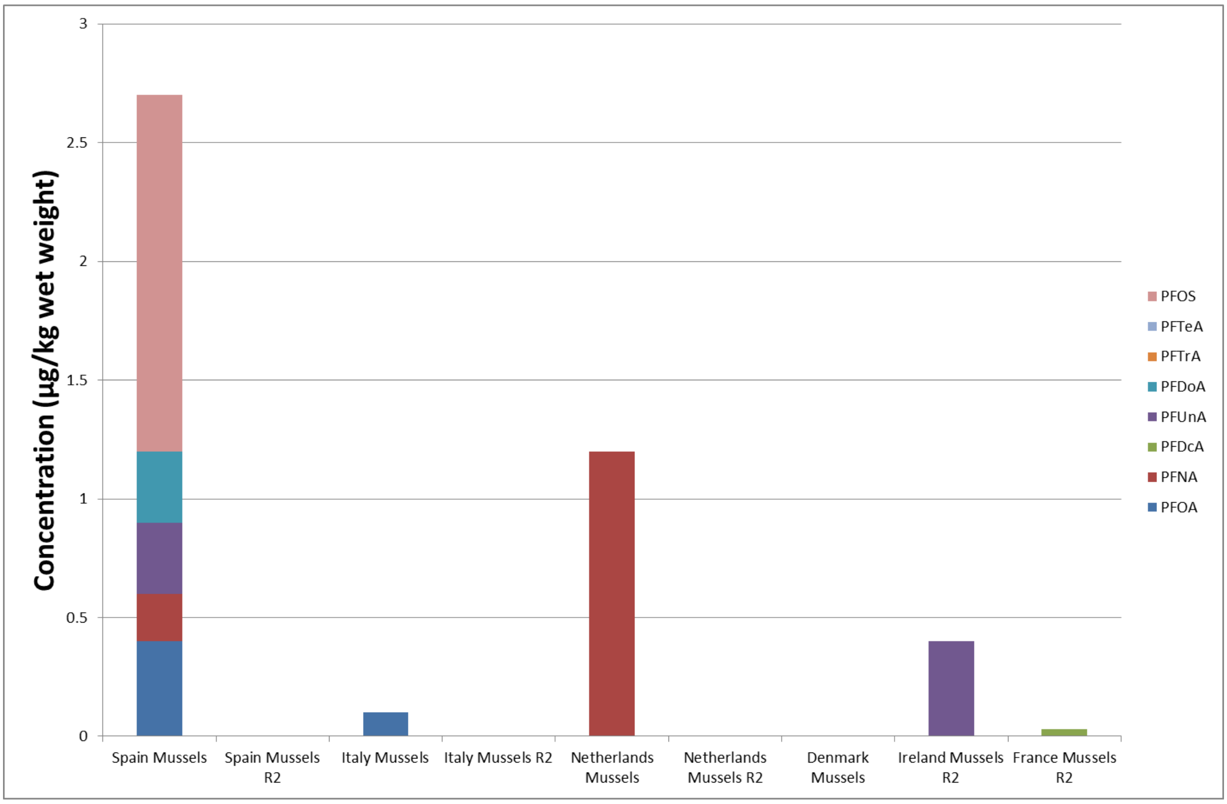

Figure 18. Levels of PFCs in mussels samples from different origin at sampling round 1 and 2 (R2)

From figure 19 it can be concluded that a different origin leads to different contamination levels, when comparing the same species. Hake from South Africa presented higher levels than from South America. To put the levels in perspective, the levels in other seafood is shown too.

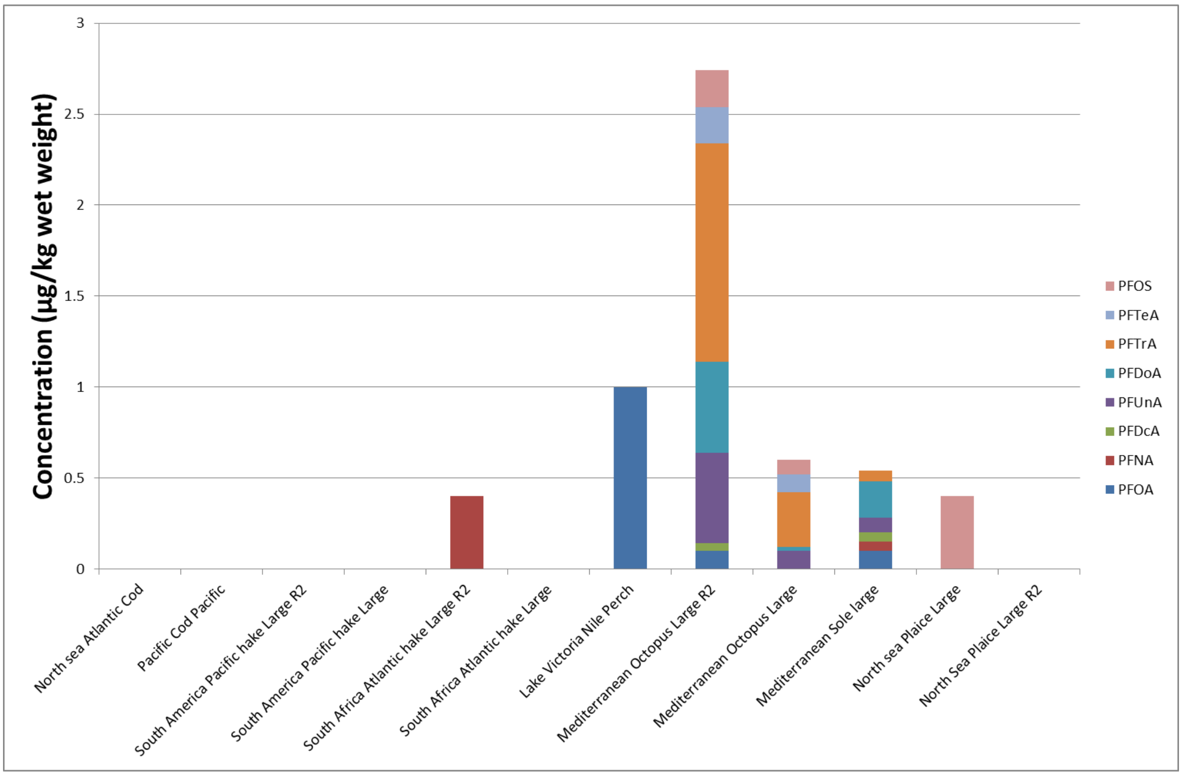

Figure 19. Levels of PFCs in several seafood samples from different origin at sampling round 1 and 2 (R2)

Conclusions:

-In general, low levels, close to the LOQ.

-Effects of location on levels, as well as composition, have been observed

2.7 PAHs:

PAHs were only determined in mussels and crab, as fish is capable of metabolisation of PAHs.

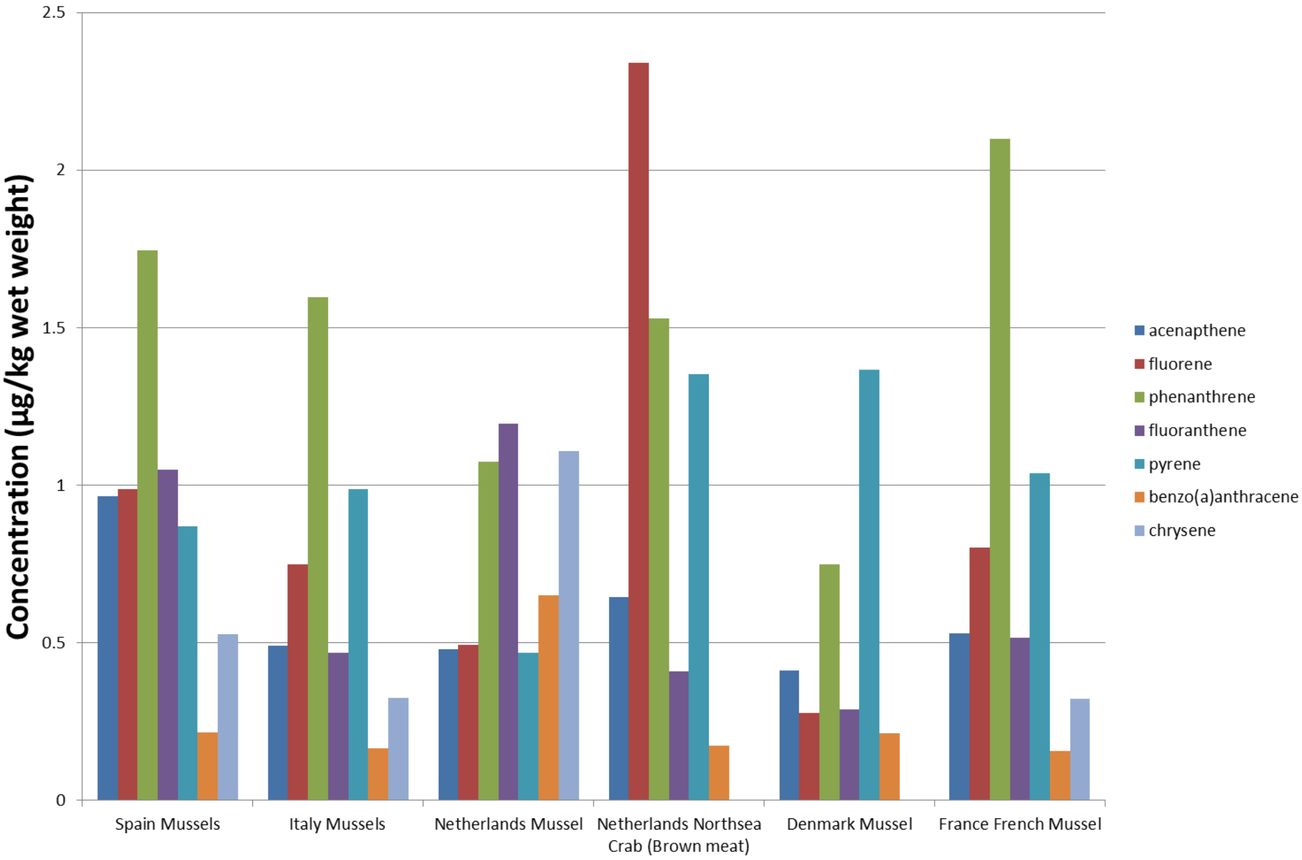

Figure 20. Levels of low molecular weight PAHs in mussel samples from different locations in round 1, as well as North Sea crab.

Figure 20 and 21 show PAH levels in mussels from different locations in Round 1. Dutch mussels were higher in PAHs, especially the high molecular weight (5-6 rings) PAHs.

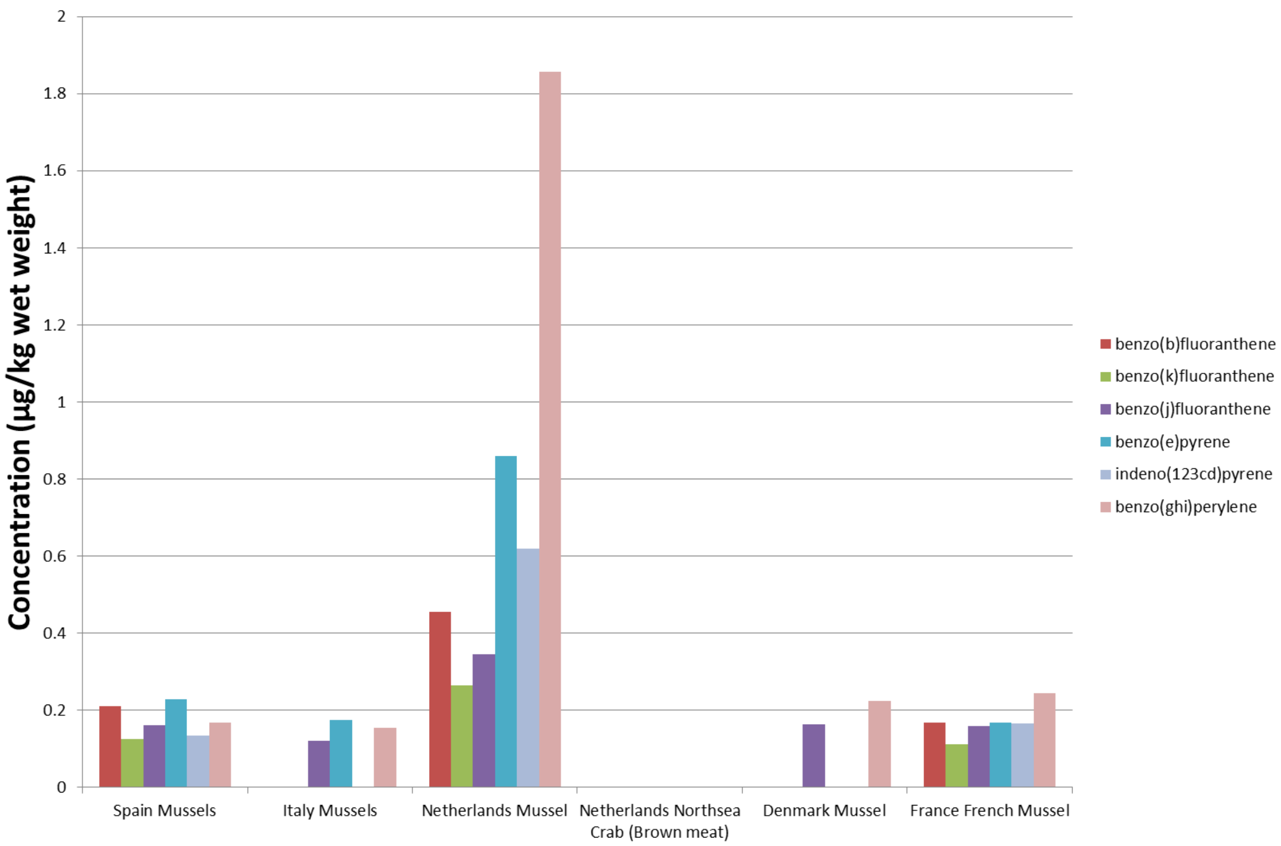

Figure 21. Levels of high molecular weight PAHs in mussel samples from different locations at round 1, as well as North Sea crab.

Surprisingly the levels of LWM (low molecular weight) PAHs were high, whereas the levels of HWN (high molecular weight) PAHs were very low in brown meat of Northsea crab.

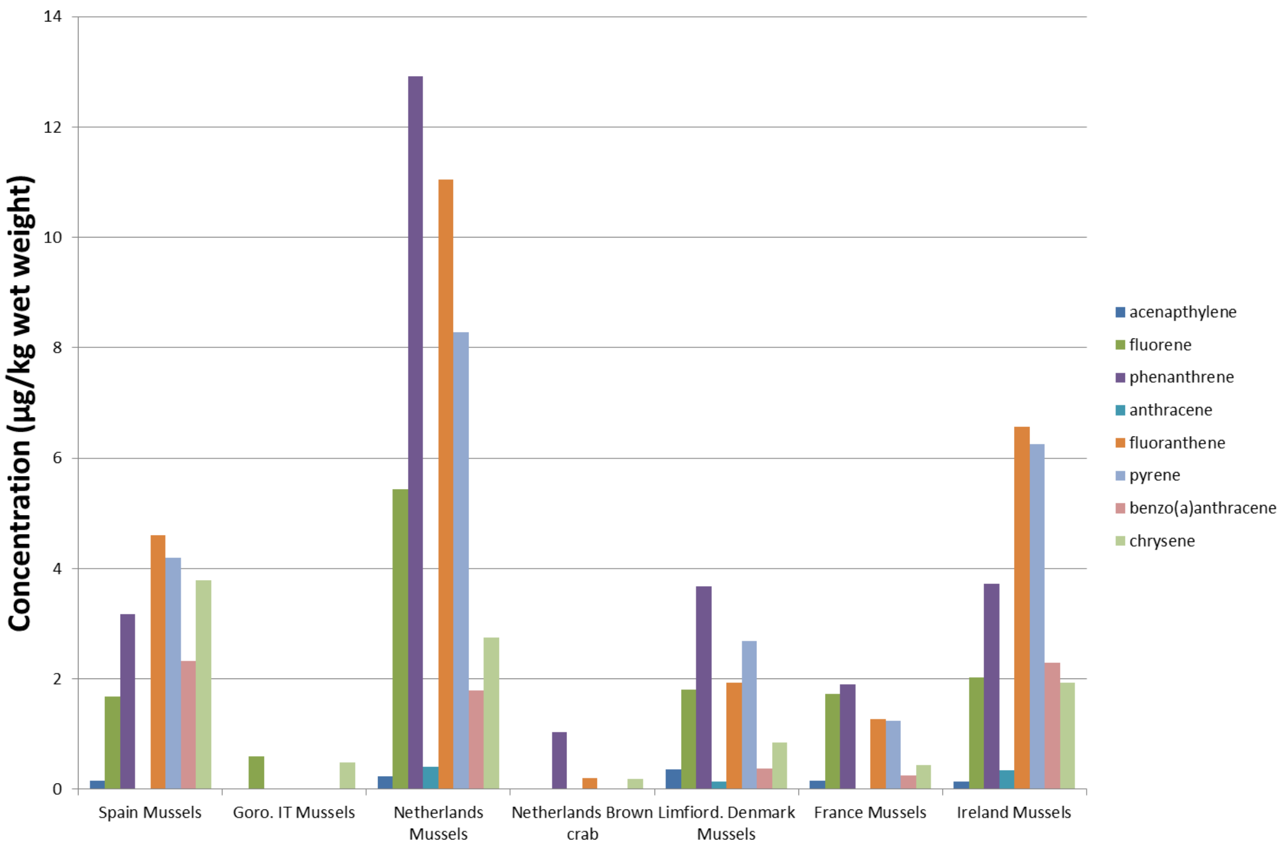

Figure 22. Levels of smaller PAHs in mussel samples from different origin at round 2

Figure 22 and 23 show that in Round 2 the levels as well as profiles were different from Round 1.

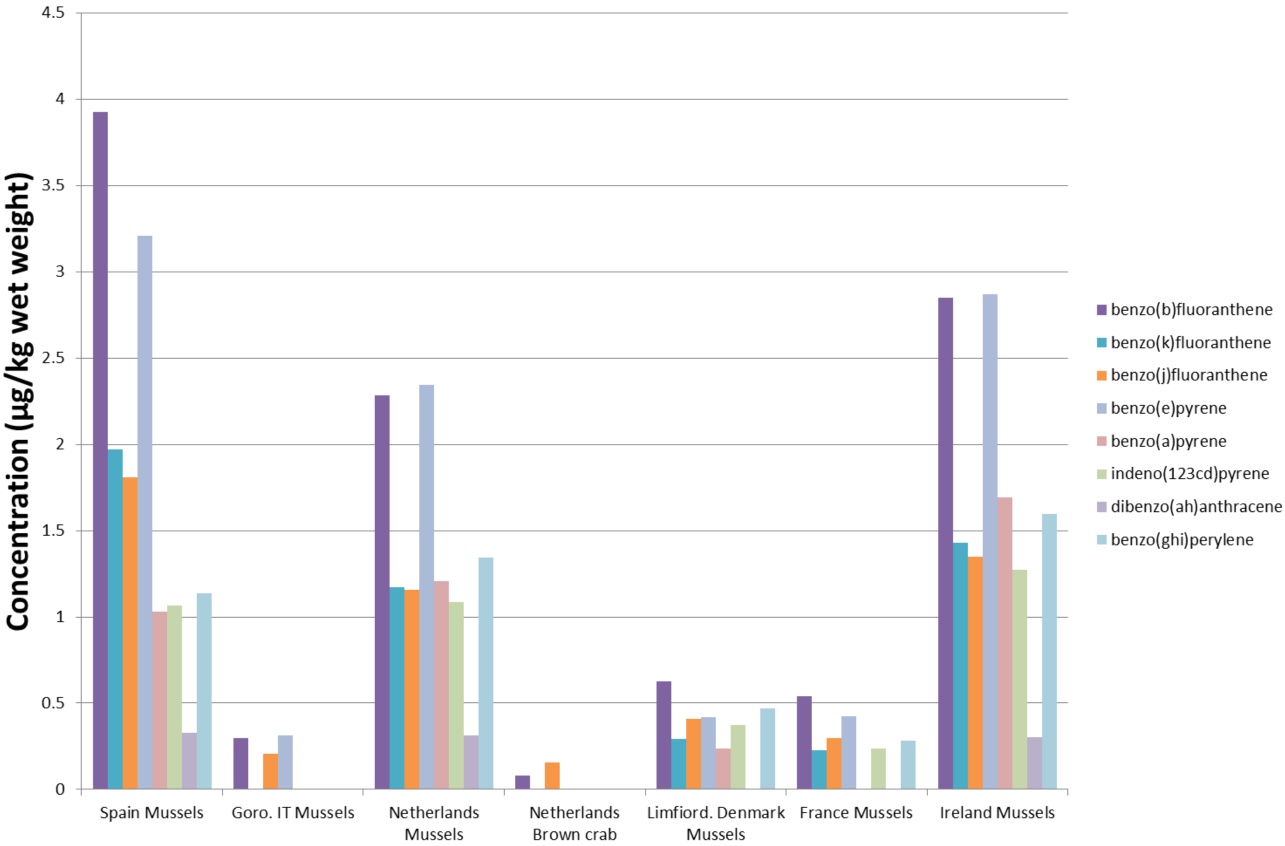

Figure 23. Levels of larger PAHs in mussel samples from different origin at round 2

The levels and profiles in mussel are fairly similar, polluted and clean areas can be observed. It is curious to see that levels in Round 2 are higher than in Round 1. The Spanish mussels have the highest levels of HMW PAHs, while the mussels from the Dutch location contain (relatively) higher levels of LMW PAHs.

2.8 Levels in farmed species

The levels of pollutants in farmed seafood are not a reflection of the water quality of the location they are farmed, but of the feed used by the farmers.

Figure 24 clearly shows that pangasius and salmon farmed (round I) in Denmark are fed feed with low mercury content. The seabream has clearly been fed with feed with higher mercury content. The very low levels of mercury in pangasius, lower than in any other analysed seafood, shows that they are fed with high quality feed.

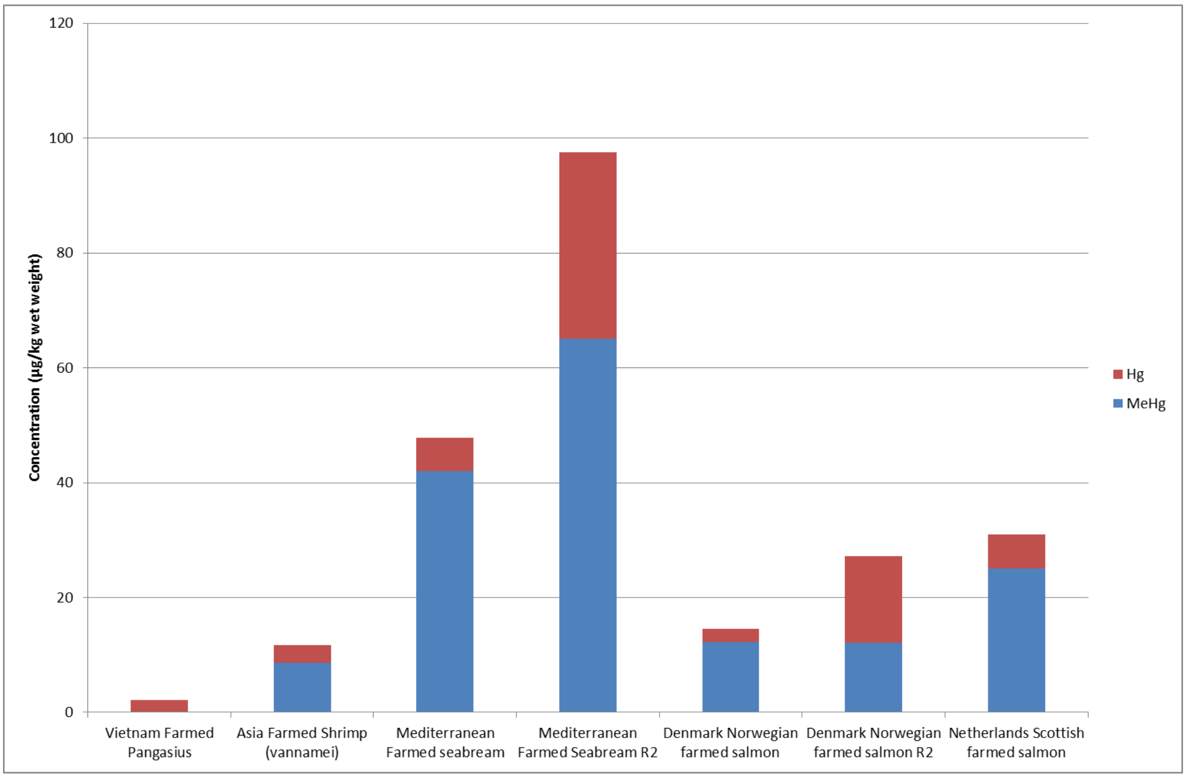

Figure 24. Levels of mercury in farmed species samples from different origin at sampling round 1 and 2 (R2)

The analysis of PBDE in farmed seafood confirms that location, that is feed used, has a very large influence on the levels in the seafood (Figure 25). These figures also show that the farmed seabream from round 2 was fed with a distinct different feed than the fish from round 1, the levels of all contaminants were higher in the fish of round 2.

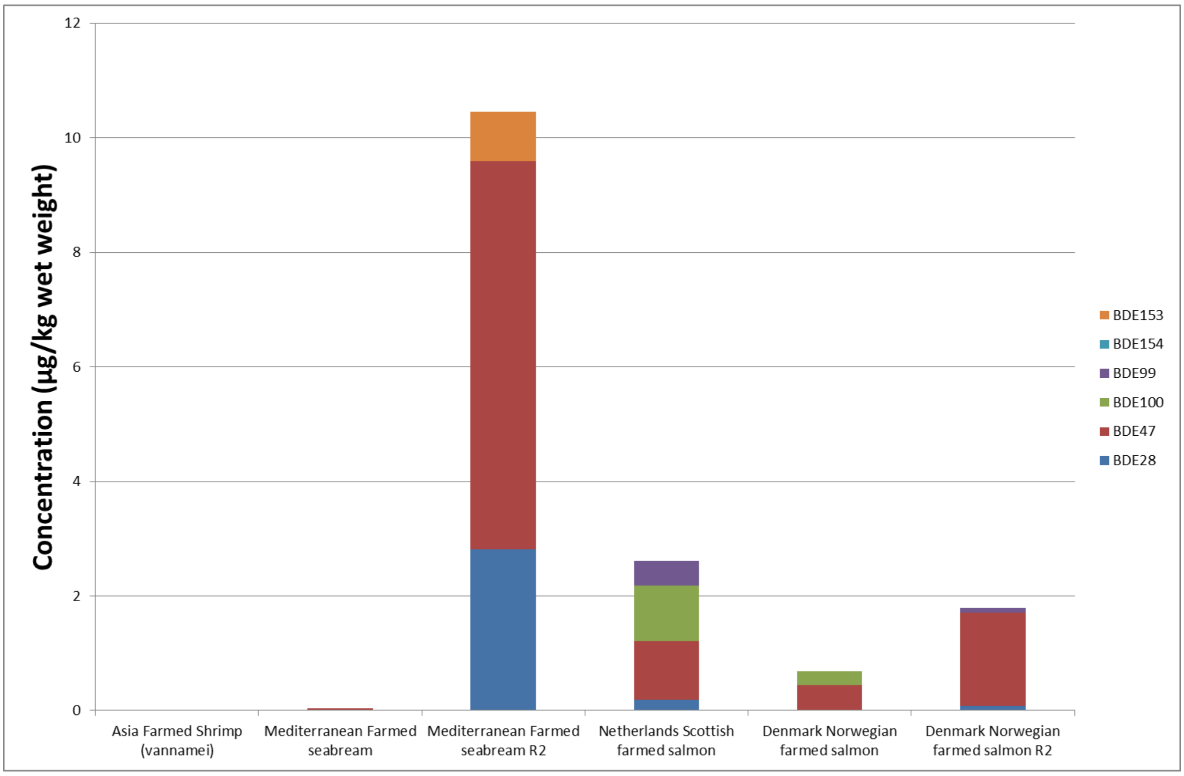

Figure 25. Levels of PBDEs in samples from farmed species at different locations in round 1 and 2 (R2)

The levels of new BFRs seem to be very different between the farmed fish species, perhaps caused by a local condition, not related to the feed (Figure 26). HBB was only detected in the seabream from round 2 (Figure 27).

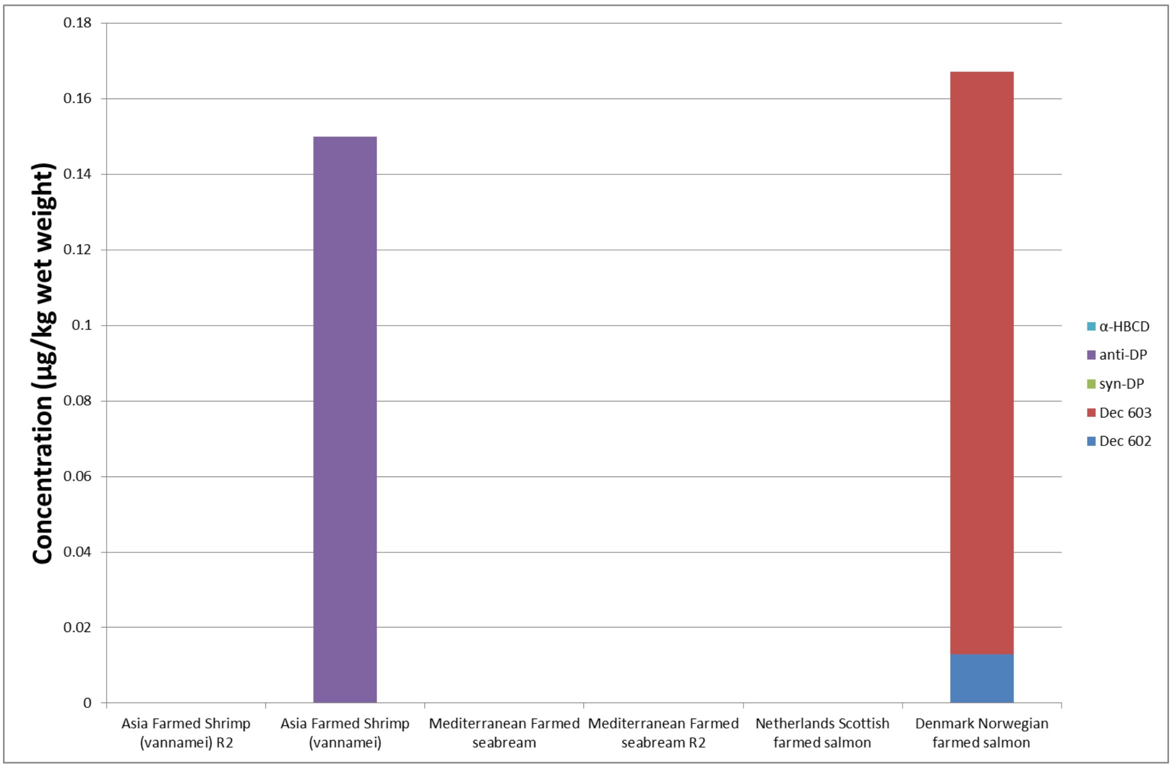

Figure 26. Levels of new BFRs in samples from farmed species at different locations in round 1 and 2

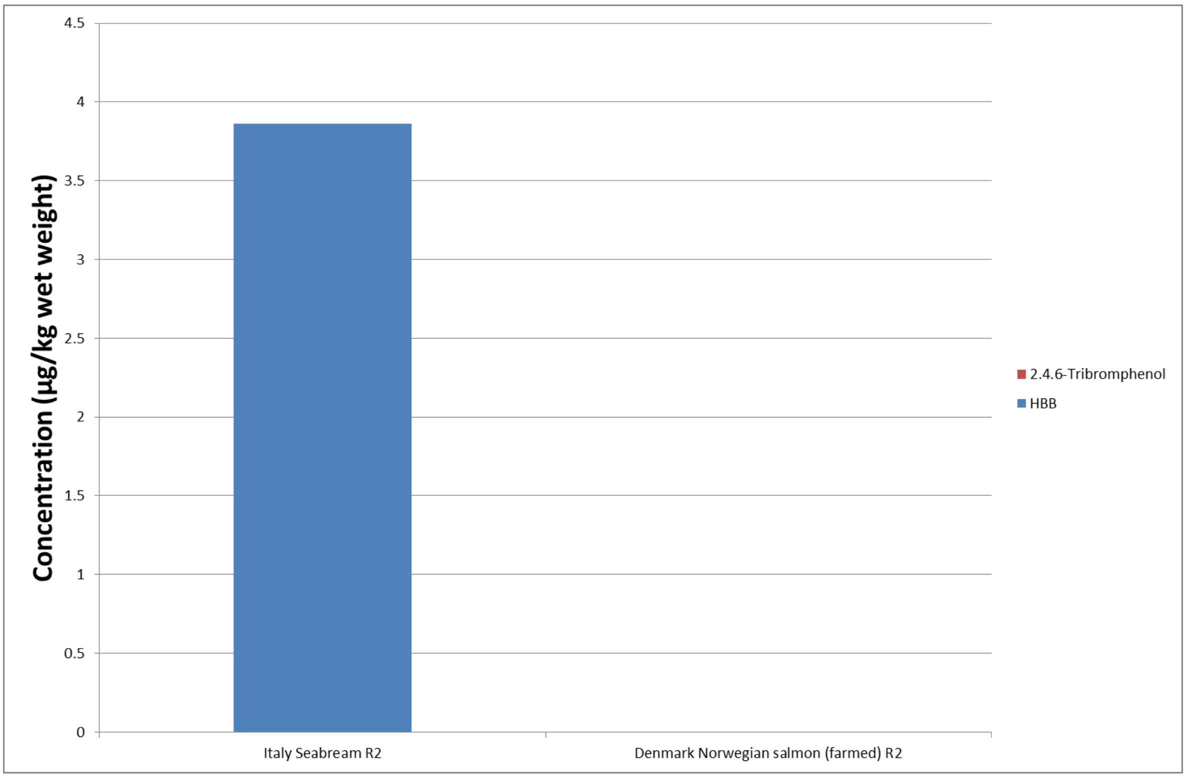

Figure 27. Levels of HBB and tribromophenol in farmed fish from different locations in sampling round 2

The levels of MBDEs was also very different between the farmed fish species (Figure 28). Farmed seabream presented higher contamination levels, probably due to the type of feed used for this species.

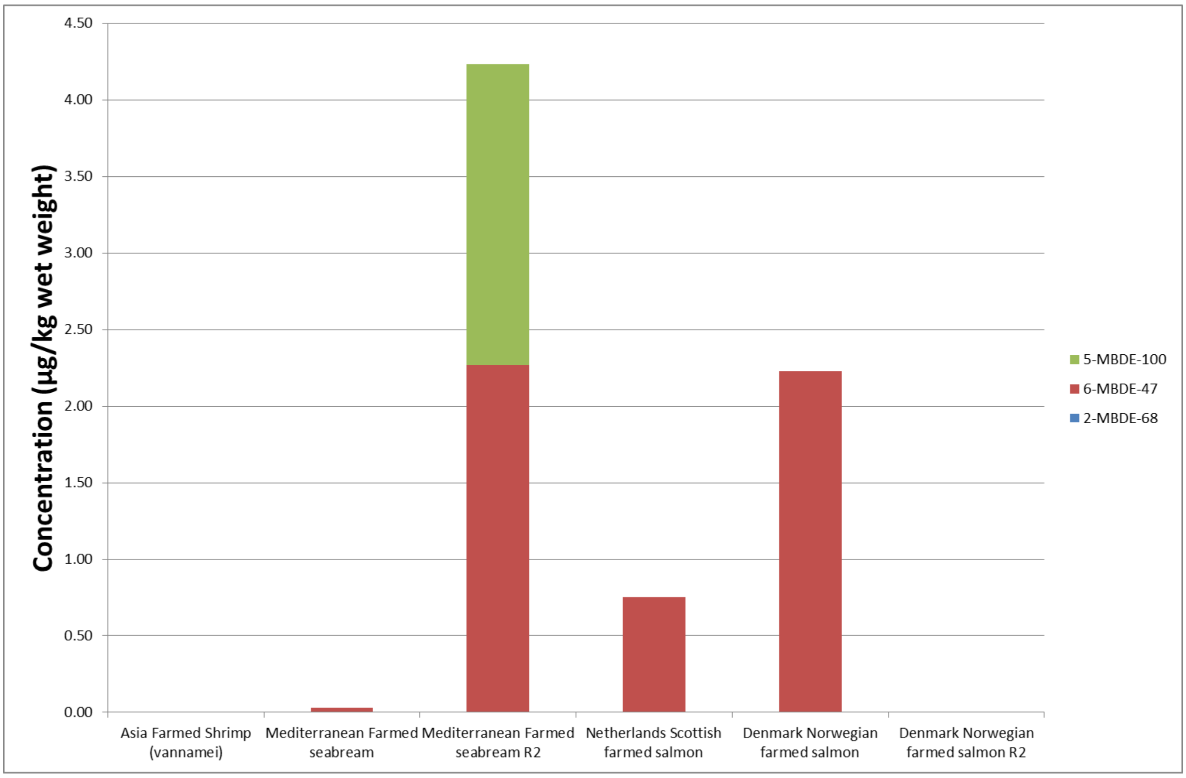

Figure 28. Levels of MBDEs in farmed species from different locations in sampling round 1+2 (R2)

Levels of PFCs were extremely low in farmed species. Only in the seabream it could be quantified as shown in Figure 29.

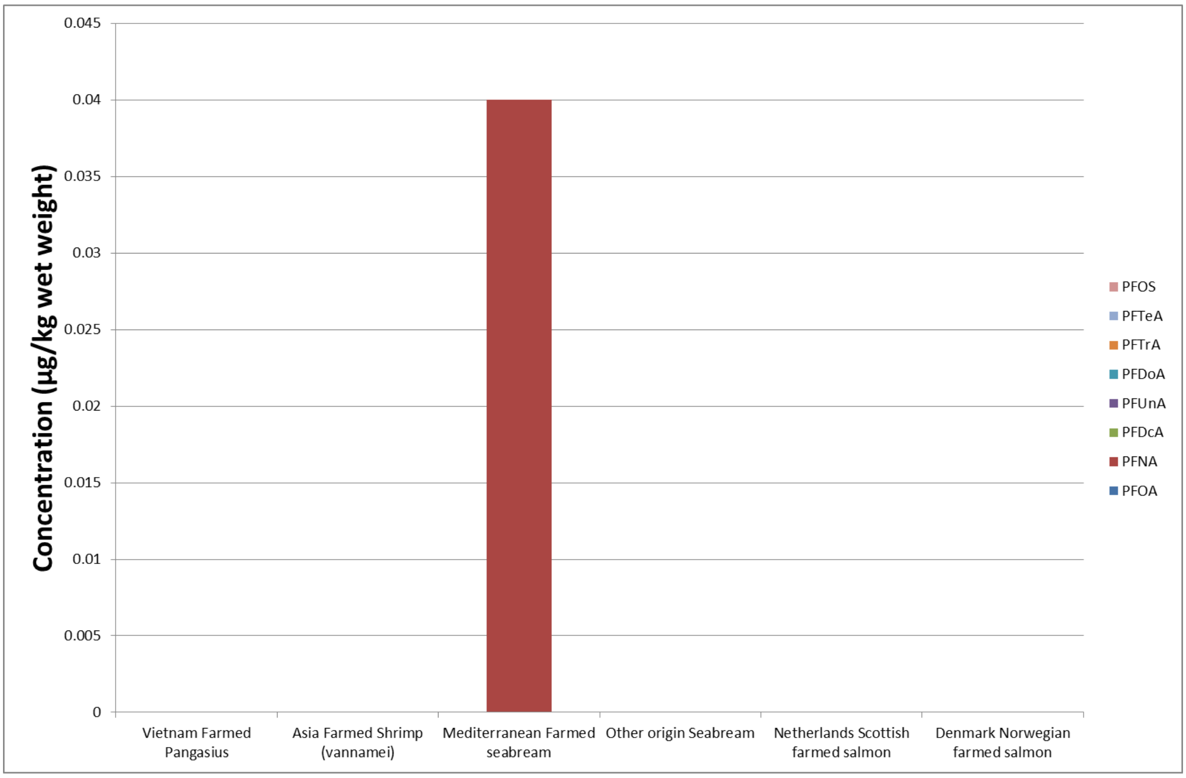

Figure 29. Levels of PFCs in samples from farmed species.

3. Conclusions

Overall, the effect of the origin on the contaminant levels in seafood species can be very large;

Some locations are clearly associated to higher levels of contamination. Next to this, each location can be associated with different profiles of environmental contaminants (table 1).

In more detail, it is also observed that

- **Italy:** was the location with highest contamination levels for the most of the contaminants studied, when compared with other locations. T-Hg and MeHg where found with highest values in mackerel, mussels and sole; PBDEs and HBB in mackerel and mussels and MBDEs in mussels

- **North Sea:** was the second location with higher contamination levels. Increased levels of T-Hg, MeHg, PBDEs, MBDEs and BFRs were found in cod. These last one, was also found in higher levels in mackerel and mussels, compared to the other locations.

- **Channel:** at these location, it was observed the higher contamination level of T-Hg, MeHg and PFCs in place, and MBDEs in mackerel.
- **The Netherlands:** it was the location with the highest iAs and PAHs levels on contamination in mussels.
- **Spain:** mackerel and mussels from Spain presented increased levels of PFCs in mackerel and mussels than on the other locations.
- **Atlantic vs Pacific:** comparing with the other locations, hake from South America (Pacific) it was found higher levels of T-Hg and MeHg; while hake from South Africa (Atlantic) it was found the higher levels of PFCs.
- **Mediterranean:** sole presented the higher levels of PFCs than on the other locations.

Table 1. The origin that represents the highest contamination level for each contaminant in seafood species.

Species	iAs	T-Hg and MeHg	PBDEs	BFRs	MBDEs	PFCs	PAHs
Plaice	n.a	**Channel**	n.a	n.a	n.a	**Channel**	n.a
Mackerel	n.a	**Italy**	**Italy**	**North Sea Italy (HBB)**	**Channel**	**Spain**	n.a
Mussels	**Netherlands**	**Italy**	**Italy**	**North Sea Italy (HBB) France (2,4,6-TBBPA)**	**Italy**	**Spain**	**Netherlands**
Cod	n.a	**North Sea**	**North Sea**	**North Sea**	**North Sea**	n.a	n.a
Sole	n.a	**Italy**	n.a	n.a	n.a	**Mediterranean**	n.a
Hake	n.a	**Pacific**	n.a	n.a	n.a	**Atlantic**	n.a