**FINAL TECHNICAL REPORT**

**Project Title:**

Isotope Ratio Mass Spectrometry Analysis for Analysis and Validation of the Origin of Commercially Sold Mackerel

**Module Code:**

Marine Fisheries Ecology **SOES3017**

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**EXECUTIVE SUMMARY**

In aiming to maintain sustainable exploitation of UK fisheries through regulation of fishing activity in these waters, it is important that the geographic origin of the fish products can be independently verified to discourage fraud. Previous studies have found that the isotopic composition of fillet tissue differs according to the lifetime geographic location/s and diet of the fish. It is possible to compare these data against reference data banks from fish caught in known locations to verify the geographic origin of these fish products. This study aims to determine whether it is likely that the products of several UK retailers contain fish caught in UK fisheries.

In this study, Mackerel products containing fillet tissue from suppliers Waitrose, John West, Sainsbury’s and J&S Seafood were sampled. From these samples the ratios of Carbon stable isotopes 13C and 12C and Nitrogen stable isotopes 15N and 14N were determined using Isotope Ratio Mass Spectrometry (IRMS). These data were then compared against a reference stable isotope composition dataset using data sourced from four different studies containing isotopic composition data from fish caught in the Celtic Sea, North Sea, Barents Sea, Irish Sea, and the Icelandic Sea.

Isotope data analyses indicated the following:

* All samples showed stable isotope composition variance within the expected range of either the Celtic, North or Barents Seas
* Only one sample was outside of the range for the North Sea

However, these data only represent a limited sample base and not necessarily market-wide product source variation

**It is concluded that it is most likely that all the products sampled in the study contained exclusively fish caught in UK fisheries.**

**1.0 EXPERIMENTAL PROCEDURES**

**1.1 Samples**

Canned Mackerel products were sampled from the following retailers:

* Waitrose (labelled as either various North Atlantic locations or Scotland and the North Sea)
* John West (labelled as from the Atlantic)
* Sainsburys (labelled as from the North-East Atlantic)
* J & S Seafood (labelled as from Scotland)

For each product, multiple samples of at least 1cm3 of tissue were taken and wrapped in tin foil.

**1.2 Methodology**

The samples were taken and freeze-dried, after which they were ground into a fine powder. Isotope ratio mass spectrometry was used to determine the stable isotope composition of these samples. The density four stable isotopes were determined: 13C, 12C,15N and 14N, and a Carbon to Nitrogen ratio was established.

**1.3 Reference Data Collection**

A reference data bank of North East Atlantic Mackerel stable isotope composition was generated using data obtained from the following North-East Atlantic sources:

* Jennings, Cogan (2015) – Data for North Sea, Celtic Sea, Irish Sea stable isotope composition
* Kim et al (2015) – Data for Norwegian Sea stable isotope composition
* Chouvelon et al. (2014) – Data for Barents Sea stable isotope composition
* Sarà et al. (2009) – Data for Icelandic Sea stable isotope composition

**2.0 RESULTS AND DISCUSSION**

**2.1 Reference data**

The 6 different clusters created through cluster analysis showed the data from the Barents and Icelandic Seas to be easily distinguishable from other groups. However, large overlap in chemical composition is seen between the North Sea, Irish Sea and Celtic Sea, and the Norwegian sea and North Sea.

Figure 1 represents the d15N and d13C isotopic ratios of the reference data. Figure 2 represents the results of cluster analyses performed on the reference data isotopic composition ratios. Clusters 2, 3 and 5 generated broadly correspond with geographic data variance for the cases of the Barents, Icelandic and Norwegian seas respectively, however the remaining clusters do not accord with much of the variance of the remaining Seas.

***Figure*** *1 – Plot of reference data isotopic composition ratios by catch location*

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Description automatically generated***Figure 2*** *–Generate Cluster analysis of reference data*

This similarity can further be observed in figure 3. Figure 3 indicates that there is relatively low variance within the non-UK fisheries compared to the UK fisheries and on the other hand, there is significant overlap between these and the UK fisheries; in the case of the Norwegian Sea in fact, the entire variance is contained within the larger North Sea spread.

***Figure 3*** *– Scatter graph of d15N:d13C variance according to catch location (See Figure 1). Location trends are highlighted in ellipses.*

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However, these analyses show overall that whilst there is significant overlap in many areas between UK offshore Seas and the Icelandic, Barents and Norwegian Seas, the data do show observably different variance according to geographic origin. Accordingly, for some areas, ascertainment of geographic origin of samples through comparison of stable isotope composition with these reference data would be possible.

**2.2 Verification of Geographic Origin**

As can be seen in figure 4, the majority of the variance observed within the Mackerel samples fit within the variance observed for the North Sea, Celtic Sea and Irish Sea. More specifically, the Sainsburys Mackerel samples all fit solely within the North Sea reference data spread. The John West and Waitrose samples also all fit within this spread, but also within the reference data spread for the Celtic sea.

***A close up of a map

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It would be impossible to determine the exact sea of origin of these samples, however it is clear these products have been sourced from seas offshore of the United Kingdom.

Two out of four J&S samples are all located within the Northern Sea and Celtic Sea spreads, however with the aforementioned outlier placing outside of these and within the Barents Sea.

It is unclear whether this is the result of J&S Seafoods sourcing from the Barents and the Celtic/Northern seas or whether this is simply a larger variance than exhibited in the reference data spread. Most likely, the 4 J&S samples are sourced from the Celtic Sea and the placement of the outlier in the Barents ellipse is due to isotopic similarity between the two seas with a slightly higher Celtic Sea isotopic composition variance than the reference data would suggest.

**3.0 CONCLUSION**

The stable isotope data obtained from the sampled canned Mackerel products of four different UK fish retailers has shown that these data are in line with the expected variation found within a reference data bank used for the North Sea, Celtic Sea and Irish sea. These reference data isotopic composition values have been shown as, with one exception, completely outside of the range of non-UK expected isotopic composition variance. The conclusion of this study is that these data show the products sampled as being sourced from UK fisheries. A conclusion cannot be made however as to the degree to which the samples taken represent the market-wide variety within the products sampled, and as a result, this study cannot determine whether all examples of these products sold on the market contain fish caught in UK waters.

**4.0 REFERENCES**

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**Appendix:**

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| --- | --- | --- | --- | --- | --- | --- |
| Cluster | Barents Sea | Celtic Sea | Icelandic Sea | Irish Sea | North Sea | Norwegian Sea |
| 1 | 0 | 7 | 100 | 3 | 4 | 0 |
| 2 | 0 | 2 | 0 | 0 | 43 | 99 |
| 3 | 0 | 6 | 0 | 0 | 78 | 0 |
| 4 | 50 | 7 | 0 | 8 | 0 | 0 |
| 5 | 0 | 41 | 0 | 6 | 51 | 0 |
| 6 | 0 | 0 | 0 | 0 | 61 | 0 |

UNCERTAIN

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Description automatically generated***Table 1***: A table generated from cluster analysis, displaying a number of data points within the cluster belongs to corresponding ocean.

***Figure 1*** *– Plot of reference data isotopic composition ratios*

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***Figure 3*** *– Ellipse graph of d15N:d13C variance according to Sea*

***Figure 4****– Plot of Retail sample stable isotope composition against variance of data from known locations*

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***Figure 6 –*** *Histogram of 𝛿13C abundance, showing North Sea and retail samples*

***Figure 5 –*** *Histogram of 𝛿15N abundance, showing North Sea and retail samples*