



Roinn Cumarsáide,
Fuinnimh & Acmhainní Nádurtha
Department of Communications,
Energy & Natural Resources



**Geological Survey of Ireland Research Programme
- Short Call 2015, Final Report -**

Name of Lead Investigator	Audrey Morley
Email	Audrey.morley@nuigalway.ie

Organisation name	National University of Ireland Galway
Organisation type:	☒ HEI ☐ Public Sector (other) ☒ Private Sector
Department/section	School of Geography & Archaeology

Project Title	Deposition and accumulation of microplastics and pollutants in marine sediments from the Irish continental shelf
Contract No.	2015-sc-058



1. NEW Partner information – (in addition to those named in project proposal)

please copy table as needed:

Co-applicant name	
Role in the project	
Organisation name	
Organisation type:	☐ HEI ☐ Public Sector (other) ☐ Private Sector
Company Registration No. (if applicable)	
Department/section	
Address	

Co-applicant name	
Organisation name	
Organisation type:	☐ HEI ☐ Public Sector (other) ☐ Private Sector
Company Registration No. (if applicable)	
Department/section	
Address	

Staff funded by the GSI Short Call Project (add lines if required)

Name	Male/female	Position	Expertise
Jake Martin	male	Research Assistant	microplastics

2. Project information:

Title of project	Deposition and accumulation of microplastics and pollutants in marine sediments from the Irish continental shelf
Did you make any formal amendment to the project workplan / budget?	☐ yes ☒ no If yes, please specify:

Project Report (max 1500 words, excluding figures and headings):

(i) Objectives and scientific/engineering targets beyond the state of the art

The aim of the overall project was to provide an assessment of microplastics in continental shelf sediments from the Irish marine environment.

Specific Scientific Research Objectives of the proposed work:

1. Develop a standardised method for the quantitative analysis of microplastics in sediment samples.

Two extraction methods were compared to develop a protocol for recovering microplastics from sediment cores. Heavy liquid floatation using sodium polytungstate (SPT) ($\text{Na}_6\text{H}_2\text{W}_{12}\text{O}_{40}$) was compared against dry sieving of sediment subsamples. Heavy liquid floatation of microplastics was conducted under a fume hood by submerging a 63 μm mesh net containing the coarse fraction of a subsample into a 1.65 g/ml solution of SPT. Floating microplastics were then extracted from the surface of the heavy liquid using a ladle. For the second method, we used interlocking sealed stainless steel sieves of different

sizes to dry-sieve sediment samples. Sieves were shaken for approximately 3 minutes initially and re-shaken for approximately 5 seconds between inspections of size intervals. Size fractions examined were 5,000-500 μm ($\geq 500 \mu\text{m}$), 499-400 μm , 399-355 μm , 354-315 μm and 314-250 μm . In order to quantify recovery rates of microplastics for both methods, sediment samples of varying grain coarseness and organic content were spiked with a known quantity of microplastic particles generated from a single piece of PVC. These ranged in size from 500-250 μm .

Sieving was selected as the most effective recovery method for single round extraction. Recovery rate tests performed on 60 spiked subsamples produced an average recovery rate of 89.0% using the sieving method. An average recovery rate of 54% was achieved for SPT floatation from 5 spiked subsamples.

2. Describe the abundance of microplastics in Irish continental shelf waters.

62 microplastics were recovered from 10 of 11 stations using box cores. The recovered microplastics appeared to be degraded from larger items, with fibres being the principal form (85%) of microplastic, followed by fragments (15%). The highest concentration of microplastics was found within the water-sediment interfaces and the top 0.5 cm of the seafloor (66%). The majority of all microplastics were contained within the top 2.5 ± 0.5 cm of sediment within the study area (97%). Microplastics were not found below 3.5 ± 0.5 cm of sediment at any station. Sediment layers examined appeared largely undisturbed based on AMS C^{14} derived age models, with no sign of significant bioturbation or other impacts. The diversity of microplastic forms recovered suggests they are sourced from a variety of land-based and maritime activities. ***Microplastics appear ubiquitous along the western Irish continental shelf, even within remote regions.***

3. Compare pollution levels (microplastics, heavy metals etc.) from areas with high urban input (including heavy industry) to cleaner, isolated areas.

For this objectives we had planned to perform XRF measurements on recovered sediment samples. While a hand held XRF gun is shared between the Ryan Institute and the School of Geography and Archaeology at NUI Galway the device was broken for most of the year and was only serviced in November 2016. We were therefore unable to investigate whether heavy metal pollution is an issue for samples in vicinity to urban or industrial areas.

4. Identify areas for future risk management, in particularly commercially important habitats.

Statistically we were not able to identify an area that is more at risk than another as volume standardisation of stations produced a mean of 7.67 ± 2.09 microplastics per station for the Aran Grounds and Galway Bay and a mean of 6.33 ± 4.91 microplastics per station for more remote areas. This places all sites examined within error of each other for microplastic abundance. To investigate this further, additional samples were taken during Celtic Voyager Cruise CV16038 in October 2016. These will be analysed by a student of the MSc in Marine and Coastal Environments of the 2016/17 cohort.

To identify if commercially important species are at risk from microplastic pollution, MSc Student Sony Fatimatuj analysed repeated sub samples of *Nephrops norvegicus* fished from the Aran Fishing grounds over a period of 6 months. Of 86 *N. norvegicus* that were analysed, 77 animals (89.5%) had microplastics in their stomachs and/or intestine. A total 196 pieces of plastic have been found in these 77 *N. norvegicus*.

The Irish Aran Grounds fishery, including Galway Bay, had a *N. norvegicus* catch of approximately €95 million in 2014. This lobster species supports the entire fishing fleet based in Ros a Mhíl (Doyle et al., 2015). Similarly to others we have demonstrated that *N. norvegicus* consume microplastic fibres and the stock may be at risk of biological impacts (see also Welden and Cowie, 2016). The potential impacts of microplastics on *N. norvegicus* include: digestive tract blockages, feeding appendage blockages, abrasions, inflammation, ulcers, toxin accumulation and the subsequent transfer of toxins to biota, carcinogenesis, liver toxicity, blockages of enzyme production, endocrine disruption, reduced fitness, reduced growth rates and reproductive failure (Rios et al., 2007; Rochman et al., 2013; Wright, 2013).

Identifying accumulation hotspots for microplastics on the seafloor is therefore critical for monitoring the health of the marine ecosystem in support of the Marine Strategy Framework Directive (MSFD) (2008/56/EC).

Summary of major Scientific Outcomes:

A distinct stratigraphic layer of microplastics appears to be forming across the western Irish continental shelf within the upper 3.5 ± 0.5 cm of sediment and hydrographic processes are leading to a wide dispersal of microplastics across the shelf. The prevalence of microplastics found in both the water-sediment interface and superficial sediments suggests high levels of exposure to both the filter and deposit feeding benthos.

Presently, microplastic sources remain unidentified within the study area, but appear to be a combination of degraded particles from larger plastic items introduced from both land-based and maritime activities. Therefore, greater effort is needed in preventing the loss of plastic items to the environment and in minimizing the degradation of plastics through actions such as protecting synthetic lines from sun exposure. The sieving of marine sediments was found to be an effective method for recovering microplastics.

Canyon heads may be accumulating microplastics in large quantities in addition to coastal zones. Further investigation is required to understand the cycling of microplastics within marine ecosystems and their effects on ecosystem health, including the assessment of the concentration levels of specific microplastic forms in different environmental compartments and the modelling of microplastic transport within dynamic systems.

(ii) Implementation (including reference to timelines, milestones, management)

Task 1: Isolation of microplastics from sediment:

This task was performed by MSc student Jake Martin in a professional and timely manner.

Task 2: Radio carbon dating of sediment cores:

Marine carbonates that originally lived on top of sediments (epi-fauna) were carefully identified by the PI for radiocarbon dating in order to determine the temporal deposition of microplastics. It was originally planned to select a sample for dating at the base of each core and another at approximately 5 cm sediment depth to avoid possible contamination with bomb radiocarbon. **However several of the cores proved to be unsuitable for dating.** For example cores with predominantly sandy sediments had no marine carbonates present for dating. Also, sandy sediments from shallow high-energy environments

would not preserve a stratigraphic history of past marine environment. Therefore it would have been wasteful to date these particular cores.

Task 3: Visual identification of potential microplastics

This task was performed by MSc student Jake Martin in a professional and timely manner

Task 4: Polymer identification of microplastics:

For this task MSc Student Jake Martin and Post-Doctoral Associate Amy Lusher travelled to Plymouth University in March 2016 to use expert facilities made available by Project Partner Prof Thompson.

Task 5: Identification of other pollution levels (including heavy metals) in the sediment.

While all samples for heavy metal analysis were prepared by MSc student Jake Martin in a professional and timely manner the equipment to measure the contaminants was out of service over the duration of the project.

(iii) Outputs (please use bullet points) – see also Appendix I

- 5 Scientific Presentations: 3 Poster, 2 Oral
- 3 Public Talks, Outreach & Teaching
- 1 Published Conference Proceeding
- 1 Internationally Peer-reviewed publication (*in prep*)
- Recommendation for Policy on Microplastics in the Irish marine environment

Impact/value of the project (Max 500 words):

Scientific discovery: Our results show for the first time that microplastic pollution is not only present in sediments of the Irish continental shelf but that it is ubiquitous. We were also able to show that most plastics can be found in the water-sediment interface and the top $2.5 \pm 0.5\text{cm}$ which is putting bottom feeders such as *N. norvegicus* at risk for ingestion. We further showed that the majority of *N. norvegicus* (90%) indeed ingested microplastics. The analysis of sediment samples for microplastic pollution is very time consuming and due to the limited timeframe of the study we were not able to determine with certainty that areas with high sedimentation rates (e.g. Aran Fishing Grounds) are more susceptible to microplastic deposition than more remote locations. For statistically robust results we need to increase our sample selection. More samples were retrieved during CV16038 in October 2016.

Policy and governance: We presented our findings at Coastwatch Europe (Nov 2016), that was attended by MSFD staff. We submitted the following recommendations for policy makers:

- Provide more grant aid for studies aimed at quantifying the threat microplastics pose to aquaculture industry
- Provide more grant aid to establish microplastic provenance
- Review of waste water treatment technology/processes
- Review of shellfish depuration procedure
- Work to reduce plastics as the main component of fishing gear

Training: The project afforded Mr Martin a unique opportunity to engage in state of the art research for his MSc project. He gained valuable experience working in a laboratory environment on an important environmental problem. During MICRO2016 he met with leading scientists in the field and made invaluable connections for his future academic career. He has presented his work on multiple platforms and has evolved into an eloquent speaker and scientist. He won the best student award and best thesis award of the Masters in Marine and Coastal Environment 2015/16. He has motivated new post-graduate students to continue on his work on microplastic pollution in marine sediments.

Appendix 1 – Publications & Presentations:

Scientific Presentations:

- **[Conference/Poster Presentation]** Martin, J.; Lusher, L.; Thompson, R.; Morley, A. (2016) Deposition and Accumulation of Microplastics and Pollutants in Marine Sediments from the Irish Continental Shelf *59th Irish Geological Research Meeting Galway, Ireland, , 20-FEB-16*
- **[Conference/Poster Presentation]** Fatimatuj, S., Morley, A., and Lusher, A., Microplastics and heavy metals in *Nephrops norvegicus* and their potential impact to the commercial market. *59th Irish Geological Research Meeting Galway, Ireland, , 20-FEB-16*
- **[Conference/Poster Presentation]** Martin, J.; Lusher, L.; Thompson, R.; Morley, A. (2016) Deposition and Accumulation of Microplastics and Pollutants in Marine Sediments from the Irish Continental Shelf *Postgraduate Research Day April 15th Galway, Ireland, , 15-APR-16*
- **[Conference/Oral Presentation]** Martin, J., Lusher, A., Thompson, R., and Morley, A. (2016) Deposition of microplastics in marine sediments from the Irish continental shelf. MICRO 2016, Lanzarote
- **[Conference/Oral Presentation]** Casserly, J., Fatimatuj Zohara, S., Martin, J., Morley, A., Lusher, A., Thompson, R., and Lynch, K. Evidence of microplastics in the Irish marine environment. Coastwatch Europe, Autumn 2016 Survey Results.

Public Talks, Outreach & Teaching

- **[Public Talk/Oral Presentation]**. Martin, J., Lusher, A., Thompson, R., and Morley, A. (2016) Microplastics on the Irish Sea floor. Atlantaquaria, Galway, June 2016.
- **[TV interview]**. Morley, A. was interviewed by **RTE1 EcoEye** in November 2016 on Microplastics in the marine environment. To be aired in early 2017
- **[Teaching]**. Additional samples for Microplastics analysis were taking during Training Cruise CV16038 in October 2016 to work towards a long-term data set for monitoring microplastics.

Published Conference Proceedings:

- **[Conference Proceedings]**. Martin, J., Lusher, A., Thompson, R., and Morley, A. (2016). Deposition of Microplastics in Marine Sediments from the Irish Continental Shelf. IN MICRO 2016: Fate and Impact of Microplastics in Marine Ecosystems.

Internationally Peer-reviewed publication

- **[Journal Paper]** Martin, J., Lusher, A., Thompson, R., and Morley, A. (20XX). Deposition of Microplastics in Marine Sediments from the Irish Continental Shelf (in prep) Marine Pollution.

Appendix 2 – Any additional information not included above: