CLIMATE CHANGE AND PLASTIC POLLUTION – SIMILAR NEEDS FOR GLOBAL ACTION

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PLASTIC IS A FANTASTIC MATERIAL, BUT WE NEED REGULATIONS, NOW!

- PLASTIC IS FANTASTIC, AND WILL SOLVE ALOT OF OUR COMMON GLOBAL PROBLEMS (ANDRADY, 2009)
  - FOOD PACKAGING
  - INFRASTRUCTURE
  - LIGHT TO TRANSPORT
  - AIR-SPACE TECHNOLOGY
  - ETC. ETC

«CLEAN MATERIAL»?

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OUTLINE OF THE TALK

- STATE OF THE RESEARCH:

  NEED FOR UNIFIED RESEARCH METHODS

- POLICY-RESEARCH INTERACTIONS:

  NEED FOR DEEP SYSTEMIC CHANGES

- POLICY:

  WHAT LESSONS CAN WE DRAW FROM THE MONTREAL PROTOCOL, WHICH ENABLED PHASING OUT OZONE-DEPLETING SUBSTANCE CFCS?

  NEED TO APPLY THE PRECAUTIONARY PRINCIPLE

1. STATE OF THE RESEARCH: IMPACTS ON EARTH'S CYCLES

- LIKELIHOOD OF BIOGEOPHYSICAL CHANGES IN EARTH'S CYCLES SUCH AS CARBON CYCLE IN THE MARINE ENVIRONMENT AND SOILS (VILLARRUBIA-GOMEZ ET AL., 2018; GALGANI & LOISELLE, 2021; RILLING ET AL., 2021)
- PLASTICS ADDED TO EXISTING PLANETARY BOUNDARIES AS PART OF "NOVEL ENTITIES", ALREADY TRESPASSED (PERSSON ET AL., 2022)

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Outside the Safe Operating Space of the Planetary Boundary for Novel Entities

Linn Persson*, Bethanie M. Carney Almroth, Christopher D. Collins, Sarah Cornell, Cynthia A. de Wit*, Miriam L. Diamond, Peter Fantke, Martin Hassellöv, Matthew MacLeod, Morten W. Ryberg, Peter Søgaard Jørgensen, Patricia Villarrubia-Gómez, Zhanyun Wang, and Michael Zwicky Hauschild

Cite this: *Environ. Sci. Technol.* 2022, 56, 3, 1510–1521
Publication Date: January 18, 2022
https://doi.org/10.1021/acs.est.1c04158

Environmental Science & Technology

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1. STATE OF THE RESEARCH: IMPACTS ON ECOSYSTEMS AND SPECIES

- MANY UNANSWERED QUESTIONS: HOW DOES PLASTIC FLOW, WHERE DOES IT GO, HOW AND HOW FAST DOES IT BREAK DOWN, WHAT IMPACTS DO PLASTICS AND ADDITIVES SUCH AS PLASTICIZERS HAVE ON HUMANS AND OTHER SPECIES?
- SO FAR HARD TO MEASURE EFFECT ON COMMUNITIES OR BIOME LEVEL (HUANG ET AL., 2021; KHALID ET AL., 2021).
  - HARD TO COMPARE STUDIES (EXAMPLE FROM MY OWN RESEARCH).
- LACK OF STUDIES MEASURING TOXICITY EFFECTS *IN SITU*, WITH WEATHERED PLASTIC RATHER THAN CLEAN PLASTIC IN A LAB ENVIRONMENT (CYVIN, 2022)

HOWEVER: WIDESPREAD EVIDENCE TO SUPPORT THAT PLASTIC AND ADDITIVES HAVE NEGATIVE IMPACTS ON SPECIES AND ECOSYSTEM HEALTH BOTH THROUGH PHYSICAL DAMAGE AND CHEMICAL TOXICITY

RECOMMENDATION 1: TO ADVANCE RESEARCH

DIVERSITY OF RESEARCH METHODS AND PROTOCOLS LEADS TO CHALLENGES IN KNOWLEDGE-BUILDING

NEED FOR HARMONIZED RESEARCH METHODS FOR:

- MICROPLASTIC MONITORING IN ARCTIC REGIONS
- UNDERSTAND HOW PLASTIC FLOWS: E.G., BOTTLE TAGS (DUNCAN ET AL., 2020)
- COASTLINE MONITORING: EU MICROLITER ASSESSMENT PROTOCOL, OSPAR
- SEDIMENT ANALYSIS (FRIAS ET AL., 2018)
- INDICATOR SPECIES: E.G. NEPHROPS NORVEGICUS (JOYCE ET AL., 2022)
- PROTOCOLS FOR SEDIMENT (BELLASI ET AL., 2021) AND WATER ANALYSIS (LEE AND CHAE, 2021) A VARIETY OF ANALYTICAL STRATEGIES ARE DISCUSSED, WHILE
- PROTOCOLS FOR BIOTA ANALYSIS (HERMSEN ET AL., 2018 & TSANGARIS ET AL., 2021)

THESE NEED TO BE REVIEWED BY THE SCIENTIFIC COMMUNITY AND ADOPTED, ADAPTED OR REPLACED

1. STATE OF THE RESEARCH: HUMANS

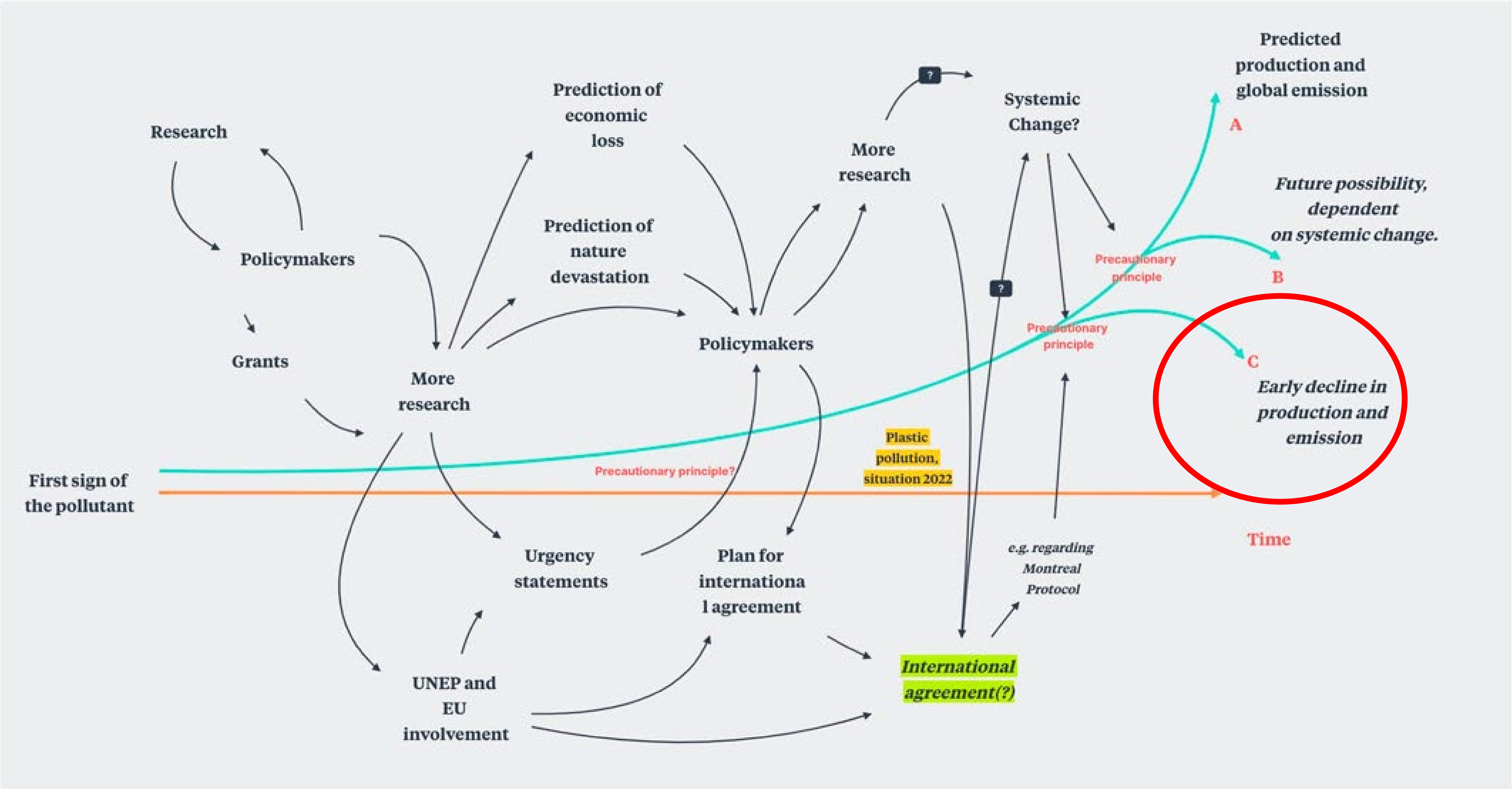
EXPERIMENTS CANNOT BE CARRIED OUT ON HUMANS FOR OBVIOUS ETHICAL REASONS; WHAT CAN BE DONE IS QUANTIFY EXPOSURE. PLASTICS FOUND IN:

- HUMAN LUNG TISSUE
- DRINKING WATER
- FOOD (MORE THAN SEAFOOD)
- PLACENTA
- NANOPLASTICS WHERE?

2. POLICY-RESEARCH INTERACTIONS

- PUSH-AND-PULL DYNAMIC BETWEEN RESEARCHERS AND POLICY-MAKERS (WATSON-WRIGHT, 2005)
- THIS HAS BEEN THE CASE BEFORE WITH OTHER ENVIRONMENTAL CHALLENGES SUCH AS THE OZONE LAYER DEPLETION WITH CFC AND CLIMATE CHANGE
- 3 SCENARIOS ACCORDING TO OUR MODEL

HOW CAN WE ESTABLISH A CONSTRUCTIVE COLLABORATION BETWEEN RESEARCHERS AND POLICY-MAKERS?



From: «Plastic pollution: about time to unify research methods and demand systemic changes». By Hellevik and Cyvin 2023.

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2. POLICY-RESEARCH INTERACTIONS

CHALLENGES FOR POLICY-MAKING:

- UNDERSTANDING THE SCIENCE AND WHY SOME QUESTIONS CANNOT BE ANSWERED EXPERIMENTALLY
- UNCERTAINTY IN SCIENTIFIC RESULTS AND HOW TO MANAGE IT
- UNDERSTANDING THAT THE MORE WE KNOW, THE MORE WE REALIZE WE IGNORE AND WHY WE CANNOT WAIT TO SOLVE EVERY QUESTIONS TO ACT
- RECOMMENDATIONS GIVEN IN RESEARCH PAPERS ON MARINE POLLUTION, "ONLY" ADDRESS 'SHALLOW LEVERAGE POINTS' OR DOWNSTREAM MANAGEMENT OF PLASTIC RATHER THAN UPSTREAM, SYSTEMIC PROBLEMS (RIECHERS ET AL., 2021)

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RECOMMENDATION 2: TO ADVANCE RESEARCH – POLICY INTERACTIONS

TO RESEARCHERS:

- EXPRESS FINDINGS CLEARLY AND COMMUNICATE BEYOND PEER-REVIEWED PAPERS
- GIVE CLEAR RECOMMENDATIONS AND DO NOT UNDERPLAY THE IMPLICATIONS OF YOUR FINDINGS
- GIVE RECOMMENDATIONS ADDRESSING DEEPER LEVERAGE POINTS FOR SYSTEMIC CHANGES (RIECHERS ET AL., 2021)

TO POLICY-MAKERS AND RESEARCHERS

- ESTABLISH COMMUNICATION BETWEEN RESEARCHERS AND POLICY-MAKERS AT VARIOUS LEVELS
- DO NOT WAIT FOR SCIENTISTS TO ANSWER ALL THE QUESTIONS BEFORE DEVELOPING AMBITIOUS POLICIES, APPLY THE PRECAUTIONARY PRINCIPLE TO PROTECT LIFE

3. POLICY-MAKING: WHAT CAN WE LEARN FROM THE MONTREAL PROTOCOL AGAINST CFC AND THE OZONE LAYER DEPLETION?

- SUCCESSFUL INTERNATIONAL COOPERATION FOR A COMPLEX PROBLEM
- SCIENTISTS INVOLVED
- UNCERTAINTY WAS EMBRACED: FLEXIBLE INSTRUMENTS PUT IN PLACE THAT COULD ADJUST REGULATIONS AS THE EVIDENCE BECAME CLEARER

THE CONCLUSION NOW FOR PLASTIC POLLUTION:

- ***PLASTIC IS DIFFERENT BUT HAS SIMILARITIES WITH CFCS AND CLIMATE CHANGE***
- ***PLASTIC IS UBIQUITOUS ACROSS INDUSTRIES BUT IN MANY CASES, IT CAN BE PHASED OUT***
- ***BEHAVIOUR CHANGE IS ALSO REQUIRED BUT THERE NEEDS TO BE A STRONG SIGNAL FROM THE TOP***
- ***CONTRARY TO CFCS, PLASTICS ARE OFTEN VISIBLE AND CHALLENGE OUR WAYS OF LIFE***
- ***WE DO KNOW ENOUGH TO USE THE PRECAUTIONARY PRINCIPLE AND MOVE TO ACTION***

Planetary Boundaries (as defined in 2023)[1]

Earth-system process	Control variable[1]	Boundary value in 2023	"Current" value (i.e. for the year provided in the source)	Boundary now exceeded beyond the 2023 values? (based on "current" value)	Preindustrial Holocene base value
1. Climate change	Atmospheric carbon dioxide concentration (ppm by volume)[10] *See also: Tipping point (climatology)*	350	417[11]	yes	280
	Total anthropogenic radiative forcing at top-of-atmosphere (W/m^2) since the start of the industrial revolution (~1750)	1.0	2.91[11]	yes	0
2. Change in biosphere integrity[1]	*Genetic diversity:* Extinction rate measured as E/MSY (extinctions per million species-years)	<10 E/MSY but with an aspirational goal of ca. 1 E/MSY (assumed background rate of extinction loss)	>100 E/MSY	yes	1 E/MSY
	Functional diversity: energy available to ecosystems (NPP) (% HANPP)	HANPP (in billion tonnes of C year−1) <10% of preindustrial Holocene NPP, i.e., >90% remaining for supporting biosphere function	30% HANPP	yes	1.9% (2σ variability of preindustrial Holocene century-mean NPP)
3. Biogeochemical	Phosphate global: P flow from freshwater systems into the ocean; regional: P flow from fertilizers to erodible soils (Tg of P $year^{-1}$)	*Phosphate global:* 11 Tg of P $year^{-1}$; *regional:* 6.2 Tg of P $year^{-1}$ mined and applied to erodible (agricultural) soils.	*Global:* 22 Tg of P $year^{-1}$;[12] *regional:* 17.5 Tg of P $year^{-1}$	yes	0
	Nitrogen global: industrial and intentional fixation of N (Tg of N $year^{-1}$)	62	190	yes	0
4. Ocean acidification	Global mean saturation state of calcium carbonate in surface seawater (omega units)	2.75	2.8	no	3.44
5. Land use	Part of forests rested intact (percent)[7]	75 from all forests including 85 from Boreal forest, 50 from Temperate forests and 85 from Tropical forests[7]	*Global:* 60[7]	yes	100
6. Freshwater change	Blue water: human induced disturbance of blue water flow	Upper limit (95th percentile) of global land area with deviations greater than during preindustrial, Blue water: 10.2%	18.2%	yes	9.4%
	Green water: human induced disturbance of water available to plants (% land area with deviations from preindustrial variability)	11.1%	15.8%	yes	9.8%
7. Ozone depletion	Stratospheric ozone concentration (Dobson units)	276	284.6	no	290
8. Atmospheric aerosols	Interhemispheric difference in AOD	0.1 (mean annual interhemispheric difference)	0.076	no	0.03
9. Novel entities	Percentage of synthetic chemicals released to the environment without adequate safety testing	0	Transgressed	yes	0

STATUS PLANETARY BOUNDARIES 2023

The only successful international agreement so far has a measurable impact:

The ozone layer depletion has been stopped! (7)

Source: Wikipedia based on Richardson et al., 2023

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RECOMMENDATION 3: POLICY-MAKING

ADOPT THE PRECAUTIONARY PRINCIPLE… NOW!

WORK TOWARDS A STRONG GLOBAL PLASTIC TREATY!

DO NOT LEAN ON THE CONSUMER LEVEL FOR SOLUTIONS: «THE PLASTIC MONSTER» - «JUST DON´T DO IT» – NOTHING WRONG FOR COMMUNICATIONS, BUT A DANGEROUS TRACK TO FOLLOW…

CROSS-DICIPLINARY COOPERATION

Interdiciplinarity often ends up as diciplines working together rather than diciplines understanding each other and working in the interface/borders between diciplines.

Lack of material scientists and polymer experts as well as economists and representation from privat industries and governements.

Lack of formal bodies, formal requirements, required metadato from analysis and sampeling, lack of relevant polymer information and lack of socio-economic analysis.

SOURCES

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- ANDRADY, A. L., & NEAL, M. A. (2009). APPLICATIONS AND SOCIETAL BENEFITS OF PLASTICS. *PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B: BIOLOGICAL SCIENCES*, *364*(1526), 1977–1984. HTTPS://DOI.ORG/10.1098/RSTB.2008.0304
- BELLASI, A., BINDA, G., POZZI, A., BOLDROCCHI, G., AND BETTINETTI, R. (2021). THE EXTRACTION OF MICROPLASTICS FROM SEDIMENTS: AN OVERVIEW OF EXISTING METHODS AND THE PROPOSAL OF A NEW AND GREEN ALTERNATIVE. *CHEMOSPHERE* 278, 130357. DOI:10.1016/J.CHEMOSPHERE.2021.130357
- DANOPOULOS, E., JENNER, L. C., TWIDDY, M., AND ROTCHELL, J. M. (2020A). MICROPLASTIC CONTAMINATION OF SEAFOOD INTENDED FOR HUMAN CONSUMPTION: A SYSTEMATIC REVIEW AND META-ANALYSIS. *ENVIRON. HEALTH PERSPECT.* 128 (12), 126002. DOI:10.1289/EHP7171
- DANOPOULOS, E., TWIDDY, M., AND ROTCHELL, J. M. (2020B). MICROPLASTIC CONTAMINATION OF DRINKING WATER: A SYSTEMATIC REVIEW. *PLOS ONE* 15 (7), E0236838. DOI:10.1371/JOURNAL.PONE.0236838
- DUNCAN, E. M., DAVIES, A., BROOKS, A., CHOWDHURY, G. W., GODLEY, B. J., JAMBECK, J., ET AL. (2020). MESSAGE IN A BOTTLE: OPEN SOURCE TECHNOLOGY TO TRACK THE MOVEMENT OF PLASTIC POLLUTION. *PLOS ONE* 15 (12), E0242459. DOI:10.1371/JOURNAL.PONE.0242459
- FRIAS, J. P. G. L., PAGTER, E., NASH, R., O'CONNOR, I., CARRETERO, O., FILGUEIRAS, A., ET AL. (2018). *STANDARDISED PROTOCOL FOR MONITORING MICROPLASTICS IN SEDIMENTS*. P4 DELIVERABLE D4.2 (GALWAY CITY, MAYO, CONNEMARA: GMIT). DOI:10.13140/RG.2.2.36256.89601/1GALGANI, L., AND LOISELLE, S. A. (2021). PLASTIC POLLUTION IMPACTS ON MARINE CARBON BIOGEOCHEMISTRY. ENVIRON. POLLUT. 268, 115598. DOI:10.1016/J.ENVPOL.2020.115598
- HELLEVIK, C. C., & CYVIN, J. B. (2023). PLASTIC POLLUTION: ABOUT TIME TO UNIFY RESEARCH METHODS AND DEMAND SYSTEMIC CHANGES. *FRONTIERS IN ENVIRONMENTAL SCIENCE*, *11*, 1232974. HTTPS://DOI.ORG/10.3389/FENVS.2023.1232974
- HERMSEN, E., MINTENIG, S. M., BESSELING, E., AND KOELMANS, A. A. (2018). QUALITY CRITERIA FOR THE ANALYSIS OF MICROPLASTIC IN BIOTA SAMPLES: A CRITICAL REVIEW. *ENVIRON. SCI. TECHNOL.* 52 (18), 10230–10240. DOI:10.1021/ACS.EST.8B01611*HUANG ET AL*
- JOYCE, H., FRIAS, J., KAVANAGH, F., LYNCH, R., PAGTER, E., WHITE, J., ET AL. (2022). PLASTICS, PRAWNS, AND PATTERNS: MICROPLASTIC LOADINGS IN *NEPHROPS NORVEGICUS* AND SURROUNDING HABITAT IN THE NORTH EAST ATLANTIC. *SCI. TOTAL ENVIRON.* 826, 154036. DOI:10.1016/J.SCITOTENV.2022.154036
- KHALID, N., AQEEL, M., NOMAN, A., HASHEM, M., MOSTAFA, Y. S., ALHAITHLOUL, H. A. S., ET AL. (2021). LINKING EFFECTS OF MICROPLASTICS TO ECOLOGICAL IMPACTS IN MARINE ENVIRONMENTS. CHEMOSPHERE 264, 128541. DOI:10.1016/J.CHEMOSPHERE.2020.128541LEE AND CHAE, 2021
- LEE, J., AND CHAE, K.-J. (2021). A SYSTEMATIC PROTOCOL OF MICROPLASTICS ANALYSIS FROM THEIR IDENTIFICATION TO QUANTIFICATION IN WATER ENVIRONMENT: A COMPREHENSIVE REVIEW. *J. HAZARD. MATER.* 403, 124049. DOI:10.1016/J.JHAZMAT.2020.124049
- PERSSON, L., CARNEY ALMROTH, B. M., COLLINS, C. D., CORNELL, S., DE WIT, C. A., DIAMOND, M. L., ET AL. (2022). OUTSIDE THE SAFE OPERATING SPACE OF THE PLANETARY BOUNDARY FOR NOVEL ENTITIES. *ENVIRON. SCI. TECHNOL.* 56 (3), 1510–1521. DOI:10.1021/ACS.EST.1C04158
- RAGUSA, A., SVELATO, A., SANTACROCE, C., CATALANO, P., NOTARSTEFANO, V., CARNEVALI, O., ET AL. (2021). PLASTICENTA: FIRST EVIDENCE OF MICROPLASTICS IN HUMAN PLACENTA. *ENVIRON. INT.* 146, 106274. DOI:10.1016/J.ENVINT.2020.106274
- RIECHERS, M., BRUNNER, B. P., DAJKA, J.-C., DUȘE, I. A., LÜBKER, H. M., MANLOSA, A. O., SALA, J. E., SCHAAL, T., & WEIDLICH, S. (2021). LEVERAGE POINTS FOR ADDRESSING MARINE AND COASTAL POLLUTION: A REVIEW. *MARINE POLLUTION BULLETIN*, *167*, 112263. HTTPS://DOI.ORG/10.1016/J.MARPOLBUL.2021.112263
- RILLING, M. C., LEIFHEIT, E., AND LEHMANN, J. (2021). MICROPLASTIC EFFECTS ON CARBON CYCLING PROCESSES IN SOILS. *PLOS BIOL.* 19 (3), E3001130. DOI:10.1371/JOURNAL.PBIO.3001130
- TSANGARIS, C., PANTI, C., COMPA, M., PEDÀ, C., DIGKA, N., BAINI, M., ET AL. (2021). INTERLABORATORY COMPARISON OF MICROPLASTIC EXTRACTION METHODS FROM MARINE BIOTA TISSUES: A HARMONIZATION EXERCISE OF THE PLASTIC BUSTERS MPAS PROJECT. *MAR. POLLUT. BULL.* 164, 111992. DOI:10.1016/J.MARPOLBUL.2021.111992VILLARRUBIA-GÓMEZ, P., CORNELL, S. E., & FABRES, J. (2018). MARINE PLASTIC POLLUTION AS A PLANETARY BOUNDARY THREAT – THE DRIFTING PIECE IN THE SUSTAINABILITY PUZZLE. *MARINE POLICY*, *96*, 213–220. HTTPS://DOI.ORG/10.1016/J.MARPOL.2017.11.035
- WATSON-WRIGHT, W. M. (2005). "POLICY AND SCIENCE: DIFFERENT ROLES IN THE PURSUIT OF SOLUTIONS TO COMMON PROBLEMS," IN *POLITICS AND SOCIO-ECONOMICS OF ECOSYSTEM-BASED MANAGEMENT OF MARINE RESOURCES*. EDITOR H. I. BROWMAN, AND K. I. STERGIOU (MARINE ECOLOGY PROGRESS SERIES) 300, 291–296.